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Examiners' Report June 2022

IAL Chemistry WCH11 01

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Introduction

The paper was accessible to most candidates and provided the full range of marks. Some candidates scored very high marks and were well prepared for the examination, showing excellent learning and teaching had taken place. Many had a sound knowledge of the specification and could demonstrate this in their explanations and descriptions. However, a small minority of students found the questions challenging and need to express their understanding of Chemistry more clearly. The calculations were generally well attempted with the main errors being in the use of significant figures and failing to use information from earlier in the question. There were no reports of candidates running out of time and the majority of candidates provided responses to the last question, indicating that the paper was not unduly long. The mean mark for the paper was 39.

Section A had an average of just under 12 marks which is slightly less than in other series. Candidates of all abilities gained marks on Q8 (electrons in boxes), Q4 (concentration calculation) and Q6a (electrons in an ion). But some questions were more challenging for the majority of candidates: Q11a (identifying metal elements from properties), Q16 (pollutants from combustion), and Q14 (heterolytic fission products).

Question 19 (a)

Some candidates found this question more difficult than expected, with a mean mark of 4 of 7.

The calculations in part ai and aii were not challenging but a minority of candidates struggled to identify information in the stem relevant to each part of the question. Candidates should be encouraged to underline information from the question as they work through past paper questions. Noting down the relevant equations would also help them focus on the information available and what they need to use for each part of the answer.

Many lost marks on part aiii by not showing their working and/or giving their answer as an ionic equation.

This answer is a good example of clearly laid out working throughout.

19 The element iron forms two chlorides: iron(II) chloride, $FeCl_2$, and iron(III) chloride, $FeCl_3$.

(2 green
3 brown)

(a) A known mass of iron powder is added to 200 cm^3 of a hot solution of iron(III) chloride with a concentration of 0.500 mol dm^{-3}. When the reaction is complete, the solution only contains iron(II) chloride.
The unreacted iron is filtered, dried and weighed.

200cm³ = 0.2dm³ of 0.5 mol/dm³ $FeCl_3$

Initial mass of iron powder = 6.17 g
Final mass of iron powder = 3.38 g

(i) Calculate the number of moles of iron that react. **(2)**

6.17 - 3.38 = 2.79 g.

Iron = 55.8g/mol

55.8 → 1 mol
2.79 → x mols

x = 0.05 mols iron

(ii) Calculate the number of moles of iron(III) chloride that react. **(2)**

0.5 mol 1dm³
x mols $FeCl_3$ 0.2dm³

(all the 0.1 reacted bc only $FeCl_2$ is left)

x = 0.1 mols

(iii) Use your answers to (a)(i) and (a)(ii) to write the **ionic** equation for the reaction of iron with iron(III) chloride. Include state symbols.
You **must** show your working. **(3)**

Fe : $FeCl_3$:
0.05 0.1
1 : 2

Fe + 2$FeCl_3$ → 3$FeCl_2$

Fe+2Fe + 2Cl₃
3 6

hot solution of iron chloride

iron powder
solution → aq

$$Fe_{(s)} + 2FeCl_3(aq) \xrightarrow{h} 3FeCl_2(aq)$$

ResultsPlus
Examiner Comments

This candidate gains all the marks for ai and aii but does not give their final answer as an ionic equation for aiii so loses a mark.

The working shown is sufficient to gain M1 for aiii.

The state symbols are correct for M3 for aiii.

The equation given is balanced but not ionic so M2 cannot be awarded.

ResultsPlus
Examiner Tip

Always show your working, even if it is not explicitly asked for – you may pick up marks for transferred error.

This is an example of a response that gains all three marks for aiii.

19 The element iron forms two chlorides: iron(II) chloride, $FeCl_2$, and iron(III) chloride, $FeCl_3$.

(a) A known mass of iron powder is added to 200 cm^3 of a hot solution of iron(III) chloride with a concentration of 0.500 mol dm^{-3}. When the reaction is complete, the solution only contains iron(II) chloride.
The unreacted iron is filtered, dried and weighed.

Initial mass of iron powder = 6.17 g
Final mass of iron powder = 3.38 g

(i) Calculate the number of moles of iron that react.

(2)

$6.17 - 3.38 = \frac{2.74}{55.8} = 0.05$

(ii) Calculate the number of moles of iron(III) chloride that react.

(2)

$0.2 \times 0.5 = 0.1$

(iii) Use your answers to (a)(i) and (a)(ii) to write the **ionic** equation for the reaction of iron with iron(III) chloride. Include state symbols.
You **must** show your working.

(3)

$\overset{0}{Fe}(s) + 2\overset{+3}{Fe}Cl_3(aq) \rightarrow 3\overset{+2}{Fe}Cl_2(aq)$

$0.1 \div 0.05 = 2.$

$Fe(s) + 2Fe^{+3}(aq) + 6Cl^-(aq) \rightarrow 3Fe^{+2}(aq) + 6Cl^-(aq)$

$Fe(s) + 2Fe^{+3}(aq) \rightarrow 3Fe^{+2}(aq)$

ResultsPlus
Examiner Comments

The candidate has used their values from ai and aii to gain the ratio so M1 is awarded. The ionic equation is correct for M2. The state symbols are valid for M3. NOTE: Benefit of the doubt will always be given for subscript numbers that may prove hard to read. The second equation here would have also gained the mark for M2 as spectator chloride ions were allowed as long as the equation is balanced.

ResultsPlus
Examiner Tip

It is a good idea to underline your final answer for emphasis.

Question 19 (b)

The average mark was just one out of four and many candidates left this part blank, showing a need to practise water of crystallisation questions.

When attempted, candidates used a variety of routes to solve this question. Unfortunately many of them erroneously used data from part a and this may have led to marks being dropped when they made inappropriate assumptions.

This is an example of a response scoring all 4 marks.

(b) **The concentration of the solution obtained in (a) is increased by heating it gently to remove some of the water. The solution is allowed to cool and pale green crystals of a hydrated iron(II) chloride, $FeCl_2{\cdot}xH_2O$, form.**
Analysis shows that these crystals contain 28.1% by mass of iron.

Calculate the number of moles of water of crystallisation, x, per mole of hydrated iron(II) chloride.

(4)

$FeCl_2 \rightarrow FeCl_2{\cdot}xH_2O$

moles $FeCl_2$ = 0.05 × 3 = 0.15 moles

$\frac{28.1}{100} \times x = 55.8$

$x = 198.5765$ g

$198.5765 = ~~n~~(55.8 + 71) - 18x$

$x = \frac{71.7765}{18}$

$x = 3.9875$

$x = 4$

ResultsPlus Examiner Comments

The response does not start well, using the moles calculated previously. However, this is ignored as the candidate moves on to use the percentage by mass of iron correctly to work out the formula mass of the hydrated compound. They have then substituted this into an equation to calculate the moles of water algebraically. The answer is rounded to the nearest integer.

ResultsPlus Examiner Tip

Waters of crystallisation should always be expressed as whole numbers, not fractions or to several decimal places.

This candidate scores 2 marks.

(b) The concentration of the solution obtained in (a) is increased by heating it gently to remove some of the water. The solution is allowed to cool and pale green crystals of a hydrated iron(II) chloride, $FeCl_2 \cdot xH_2O$, form.
Analysis shows that these crystals contain 28.1% by mass of iron.

Calculate the number of moles of water of crystallisation, x, per mole of hydrated iron(II) chloride.

(4)

$FeCl_2$	$x H_2O$
$\frac{28.1\%}{126.8}$	$\frac{71.9\%}{18}$
0.22	3.99
1	20

$FeCl_2 \cdot 20H_2O$ //

~~Fe = 28.1~~

~~28.1%~~

$28.1\% = \frac{2.79}{x}$

$x = \frac{2.79}{0.281}$

$= 9.9288$

~~Fe~~

$\therefore \%$ of Cl_2 $= \frac{7.1388}{9.9288}$

$= 71.89\%$

2%

ResultsPlus
Examiner Comments

One mark was awarded for the relative formula mass of iron(II) chloride and once for calculating the moles of water.

Unfortunately this candidate did not understand how to use the percentage by mass of iron so was never going to gain the correct answer by this method.

ResultsPlus
Examiner Tip

Attempt every question – candidates may pick up marks even if they do not find the correct answer.

At first glance this candidate has the correct answer so it could be assumed that they would gain all 4 marks. Unfortunately the candidate has made some early errors and though a mark is given for the correct answer they only score 3 out of the four marks.

(b) The concentration of the solution obtained in (a) is increased by heating it gently to remove some of the water. The solution is allowed to cool and pale green crystals of a hydrated iron(II) chloride, $FeCl_2 \cdot xH_2O$, form.
Analysis shows that these crystals contain 28.1% by mass of iron.

Calculate the number of moles of water of crystallisation, x, per mole of hydrated iron(II) chloride.

(4)

$FeCl_2$ xH_2O.

moles = $\frac{mass}{molar\ mass}$.

$55.8 + (35.5 \times 2) + 18 = 144.8$.

~~55.8~~ Fe = $\frac{28.1}{55.8}$ = 0.5.

$FeCl_2$ = 1 mol

Cl = $\frac{35}{70}$ = 0.5

∴ Cl = 35%.

100 − 63.1

	$FeCl_2$	xH_2O
mass =	63.1	36.9
molar mass =	126.8	18
moles =	$\frac{63.1}{126.8}$ = $\frac{0.4976}{0.4976}$	$\frac{36.9}{18}$ = $\frac{2.05}{0.4976}$
	1 :	4.119
	1 :	4

therefore X = 4.

ResultsPlus
Examiner Comments

The candidate has started poorly by calculating the formula mass of the monohydrate. They then try to calculate the percentage of chlorine in this compound and assume the percentage of water would be the remainder. They score one mark for the formula mass of iron(II) chloride, one for calculating the moles of water (from their incorrect percentage) and one mark for giving the answer 4 as an integer.

ResultsPlus
Examiner Tip

Practise using percentage by mass data to calculate formula masses of compounds.

Question 20 (a)

This question was well answered by the majority of candidates, as was expected. One common mistake was to omit the word number from the answer 'atoms with same protons but different neutrons' was not accepted.

This was a common response to the question.

20 Naturally occurring bromine has two isotopes: bromine-79 and bromine-81.

(a) State what is meant by the term isotopes.

(1)

Isotopes are atoms of the same element with the same number of protons and electrons but different number of neutrons.

ResultsPlus
Examiner Comments

Electrons were ignored as long as they were the same as the number of protons. Candidates should be encouraged to learn the definition without reference to electrons.

ResultsPlus
Examiner Tip

Ensure you understand the meaning of key words in the specification – writing a glossary is an excellent revision exercise.

This is an example of a response that did not gain credit.

20 Naturally occurring bromine has two isotopes: bromine-79 and bromine-81.

(a) State what is meant by the term isotopes.

(1)

Isotopes ~~are~~ they have the same Element but dipperent mass Number.

ResultsPlus
Examiner Comments

'Same element' is not equivalent to the same number as protons. Candidates were allowed to substitute atoms with elements but not omit the protons from the definition.

ResultsPlus
Examiner Tip

Ensure definitions contain the necessary detail.

Question 20 (b)

Nearly 90% of candidates gained both marks for this question. Where errors were seen it was usually that mass or atomic numbers has been entered instead of the number of neutrons.

This is a correct answer as per the mark scheme.

(b) Complete the table to show the numbers of subatomic particles in the two isotopes of bromine.

(2)

Isotope	Protons	Neutrons	Electrons
bromine-79	35	79-35=44	35
bromine-81	35	81-35=46	35

ResultsPlus
Examiner Comments

It is perfectly fine for candidates to show their working in the answer box. This candidate scores both marks.

This is an example of a one mark response.

(b) Complete the table to show the numbers of subatomic particles in the two isotopes of bromine.

(2)

Isotope	Protons	Neutrons	Electrons
bromine-79	35	79	35
bromine-81	35	81	35

ResultsPlus
Examiner Comments

The candidate has given the mass number instead of the number of neutrons for both isotopes. However, this candidate still scores 1 for the correct numbers of protons and electrons for BOTH isotopes.

ResultsPlus
Examiner Tip

Always spend any spare time at the end of the exam to check your answers.

Question 20 (c)(i)

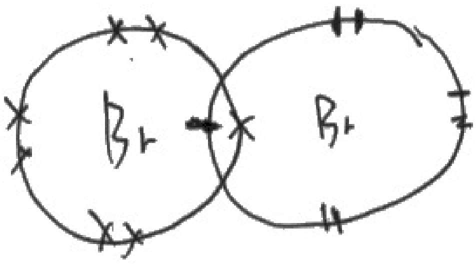
Many candidates also scored two marks for this answer. The most common reason for loss of a mark was neglecting to show the lone pairs on the bromine atoms. Benefit of the doubt was given to candidates who had attempted to cross out extra electrons, although some candidates need to be more careful in their presentation. Incorrect labelling of the atoms eg with a B instead of a Br was ignored for this paper.

This is an example of a correct response.

(c) The mass spectrum of a sample of bromine is obtained.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of bromine. Only the outer electrons should be shown.

(2)



ResultsPlus
Examiner Comments

Candidates are allowed to use any representation of electrons. Circles were allowed with or without overlaps.

ResultsPlus
Examiner Tip

Practice drawing dot-and-cross diagrams for molecules with single and double bonds.

This is another example of a correct response.

(c) The mass spectrum of a sample of bromine is obtained.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of bromine.
Only the outer electrons should be shown.

(2)

Br = 7 electrons

ResultsPlus
Examiner Comments

The line representing the covalent bond is ignored and it is clear that the atoms are sharing a pair of electrons between them.

ResultsPlus
Examiner Tip

Ensure you understand the differences between dot-and-cross diagrams and electron density maps, you won't get marks if you draw the wrong one.

Question 20 (c)(ii)

Over half of candidates failed to score on this question and many blank responses were seen. Some candidates drew little diagrams of mass spectrometers or continued their answer to acceleration and separation, showing that they had knowledge of this topic, but often did not give the required information in their answer.

This example was awarded both marks.

(ii) Describe the formation of the molecular ion of bromine in the mass spectrometer. Include an equation.
State symbols are not required.

(2)

Electron gun shoots out high speed electrons which knocks an electron out of the gaseous Br_2 molecule forming a gaseous molecular ion of Br_2^+.

$Br_2(g) \rightarrow Br_2^+(g) + e^-$

$Br-Br \rightarrow Br-Br^+ + e^-$

ResultsPlus
Examiner Comments

The first mark is awarded for the electron gun, though 'high speed' was also allowed as a reference to high energy.

Either of the equations given here is acceptable for M2.

ResultsPlus
Examiner Tip

Ensure you read the question very carefully. Highlighting, underlining or putting boxes around key terms, as seen here, is an excellent way to focus on what the answer needs to contain.

This is an example of a response that did not gain credit.

(ii) Describe the formation of the molecular ion of bromine in the mass spectrometer. Include an equation.
State symbols are not required.

(2)

$Br_2 \rightarrow 2Br^+ + 2e^-$
Ions are fired at Br_2, ripping away 2 electrons.

ResultsPlus
Examiner Comments

M1 is not awarded. The candidate has confused high-energy electrons with ions and the number of electrons is incorrect.

M2 is not awarded as two bromine atoms are formed rather than a molecular bromine ion. This was a common response for the equation.

ResultsPlus
Examiner Tip

Provide as much detail as you can in your answers, but you should not need more space than is provided.

This is an example of a 1 mark answer, emphasising the most common error when M1 was not awarded.

(ii) Describe the formation of the molecular ion of bromine in the mass spectrometer. Include an equation.
State symbols are not required.

(2)

$Br_2(g) \rightarrow Br_2^+(g) + e^-$

In the mass spectrometer, the bromine molecule is vaporised and then bombared with electrons which knock out/ remove electons from the molecules valence shell making it a positive ion (cation).

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Examiner Comments

M2 is awarded for the equation.

M1 is not awarded as the 'high-energy' descriptor for the electrons is omitted. 'Bombarded with' is insufficient for credit here. This was often seen and candidates need to be able to explain ionisation effectively.

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Examiner Tip

Ensure descriptions of mass spectrometry contain sufficient detail.

Question 20 (c)(iii)

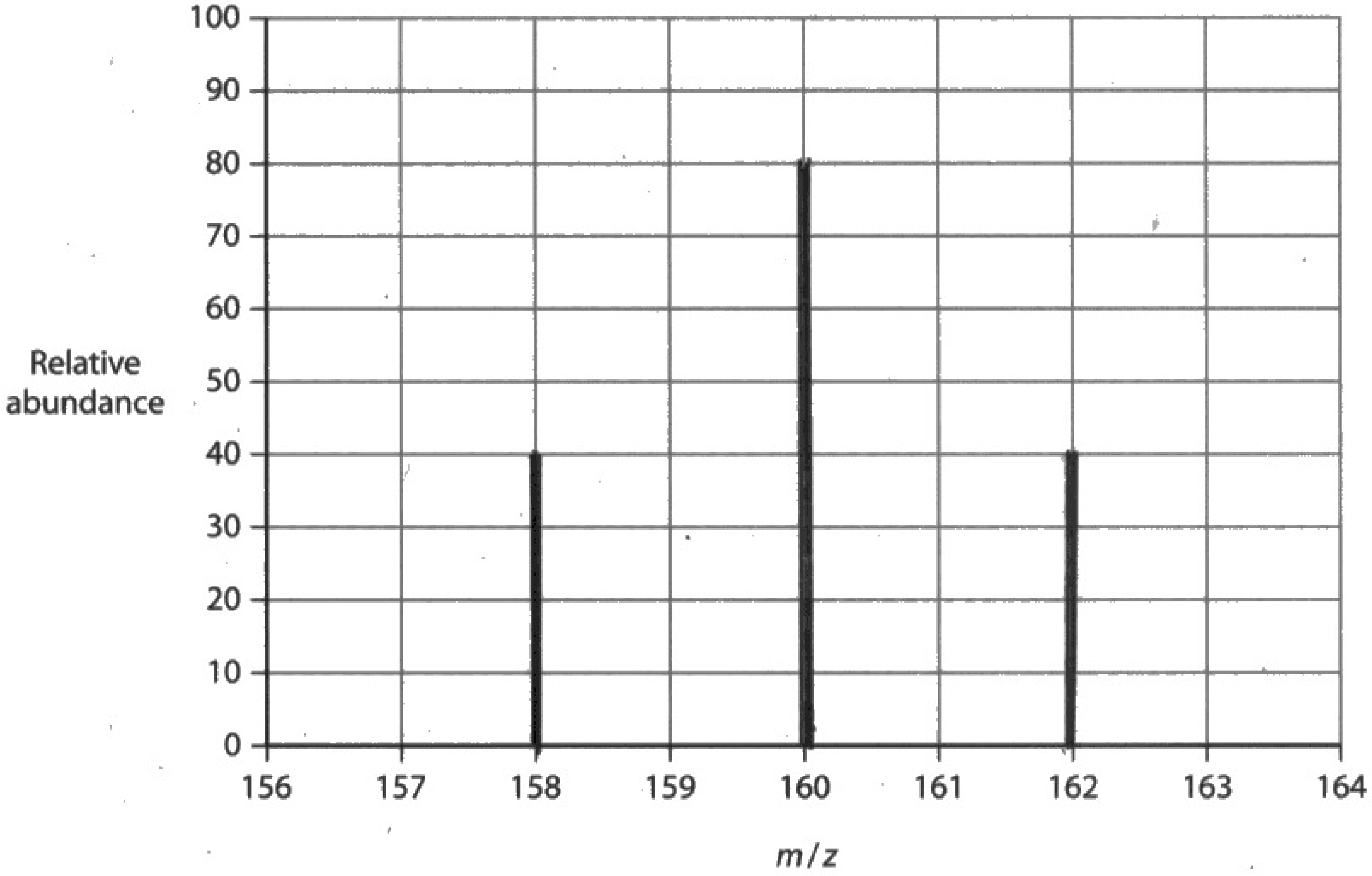
The average mark for this question was 1, with just over a third of candidates gaining both marks. Many candidates who scored both marks labelled their peaks with the isotopes that would be present in each molecular ion, showing excellent understanding. Of those who failed to score, many only drew two peaks (usually at 158 and 162 m/z) and M2 was dependent on M1. Peaks of any height were accepted, as long they were in the correct ratio, for M2.

This is an excellent example of a fully correct answer.

(iii) On the mass spectrum grid, draw the peaks for the bromine molecular ions, showing the relative peak heights.

The bromine isotopes in this sample have the **same** relative abundance.

(2)



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Examiner Comments

The candidate has emphasised the peaks rather than just drawing one line at the relevant m/z values. They have used the lines for relative abundance to help them show that the peaks on either side are half the height of the central peak.

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Examiner Tip

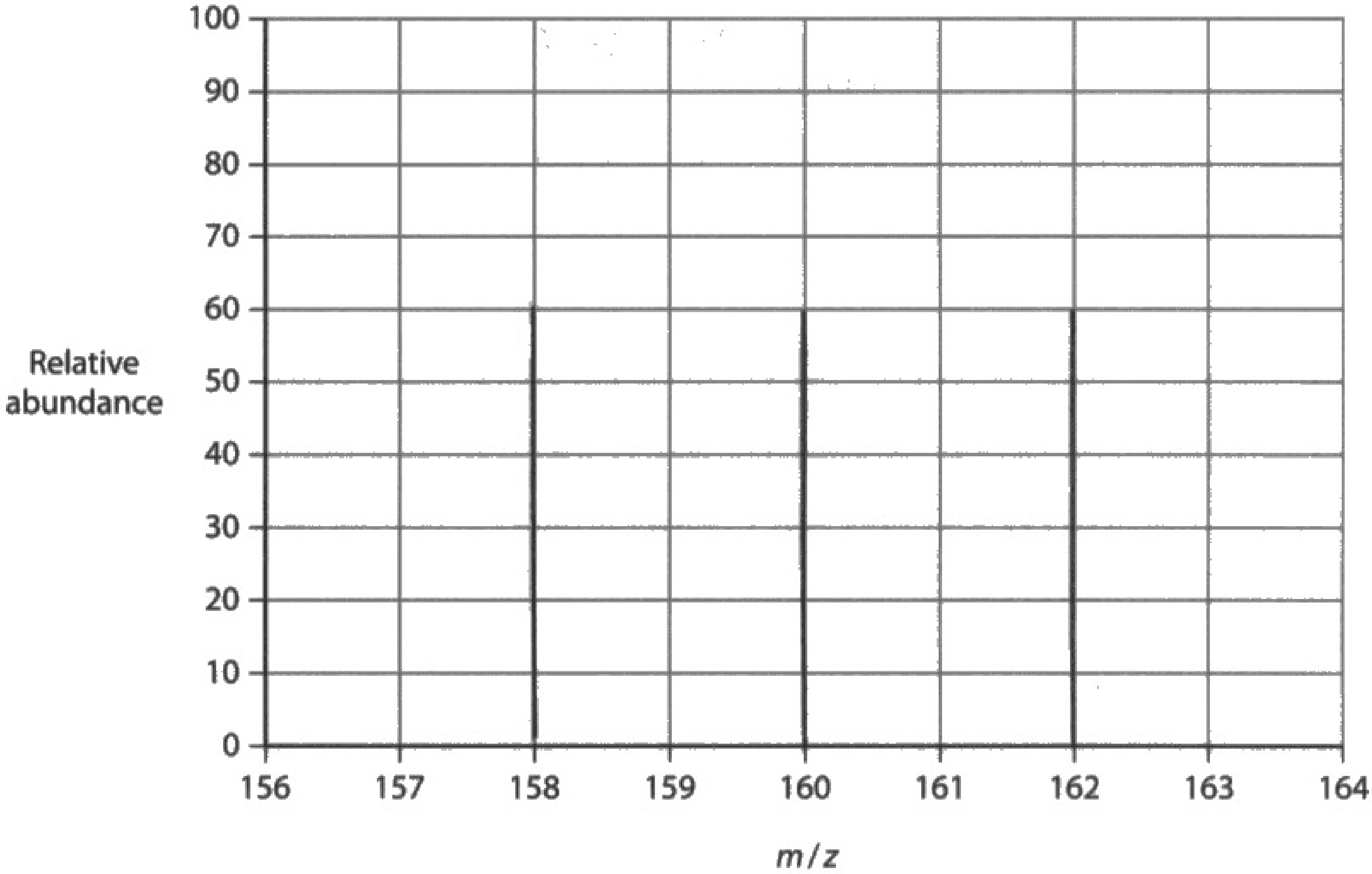
Use grid lines to help you when drawing peaks in ratios. Broader lines will help the examiner see your vertical lines on a mass spectrum.

This is an example of a response scoring only 1 mark.

(iii) On the mass spectrum grid, draw the peaks for the bromine molecular ions, showing the relative peak heights.

The bromine isotopes in this sample have the **same** relative abundance.

(2)



79 + 81 = 160
79
81

79 + 79 = 158
81 + 81 = 162

ResultsPlus
Examiner Comments

This candidate scores M1 for 3 lines at the correct m/z values. The 1:2:1 ratio is not shown in the peak heights for M2 to be awarded. The candidate has shown their working to get to the correct molecular ion masses underneath.

ResultsPlus
Examiner Tip

Use blank spaces if you need to work out answers, you will never be penalised for showing your working.

Question 20 (d)

Most candidates knew how to answer this type of question but over half only gained two marks as they gave the value to 2 decimal places for the relative atomic mass rather than the molecular mass, which would have scored 3 marks.

This is an example of a commonly seen 2 mark response.

(d) The percentage abundances of the isotopes in a different sample of bromine are shown.

Isotope	Percentage abundance
bromine-79	56.38 %
bromine-81	43.62 %

Calculate the relative **molecular** mass of this sample of bromine, giving your answer to **two** decimal places.

(3)

$$\frac{(56.38 \times 79) + (43.62 \times 81)}{100} =$$

$$= \frac{7987.24}{100} = 79.874 \approx 79.87$$

ResultsPlus
Examiner Comments

The expression seen at the top is sufficient for M1 to be awarded.

M2 is awarded for the 79.87. This had to be given to 2 decimal places if it was the final answer.

ResultsPlus
Examiner Tip

Check your final answers are given to the precision given in the question – this candidate used two decimal places but has not calculated the correct final mass.

This is an example of a one mark response.

(d) The percentage abundances of the isotopes in a different sample of bromine are shown.

Isotope	Percentage abundance
bromine-79	56.38 %
bromine-81	43.62 %

Calculate the relative **molecular** mass of this sample of bromine, giving your answer to **two** decimal places.

(3)

$$M_r = \frac{79 \times 56.38 + 81 \times 43.62}{100}$$

$$= 79.9$$

ResultsPlus
Examiner Comments

The expression is correct for M1.

M2 is not awarded as the final answer is not given to 2 decimal places.

ResultsPlus
Examiner Tip

Reread the instructions given in bold in the question. Bold instructions are essential for the awarding of marks.

An example of a fully correct response.

(d) The percentage abundances of the isotopes in a different sample of bromine are shown.

Isotope	Percentage abundance
bromine-79	56.38 %
bromine-81	43.62 %

Calculate the relative **molecular** mass of this sample of bromine, giving your answer to **two** decimal places.

(3)

56.38 → 0.5638

43.62 → 0.4362

~~(79 × 56.38) + (81~~

~~× 58 = 79 56.38~~

(158 × 0.5638 × 0.5638) + (160 × 0.5638 × 0.4362 × 2) + (162 × 0.4362 × 0.4362)

= 159.7448

= 159.74

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Examiner Comments

This candidate has taken an unusual route using the ratios of the molecular masses but has come to the correct answer. Candidates will never be penalised for taking unexpected but correct methods for calculations. The candidate has correctly rounded their answer to 2 decimal places for the final answer.

ResultsPlus
Examiner Tip

Set out your calculations carefully, it is useful to show each answer on a new line.

Question 21 (a)(i)

Candidates did not answer this question well. It may be that the specific example given confused their definition of a covalent bond. A lot of incorrect chemistry was ignored on this year's mark scheme so that more candidates could gain credit but over 70% of candidates scored no marks here. A common omission was not to mention the attraction between electrons and nuclei. Some candidates mentioned molecules of oxygen and others discussed the bond in carbon dioxide; this was not awarded.

This is an example of a response that gained 2 marks.

21 The elements carbon and silicon both form dioxides.

(a) Carbon dioxide is a simple covalent molecule but silicon dioxide has a giant covalent structure.

(i) Describe the covalent bond between a silicon atom and an oxygen atom in silicon dioxide, in terms of the particles involved.

(2)

The covalent bond forms due to an attraction force between the nuclei of the 2 atoms and the shared pairs of electrons. The Si shares 2 electrons with each oxygen atom, so there a total of 4 pairs of shared electrons.

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Examiner Comments

The candidate scores M1 as they have referenced the 'attraction force' and the 'shared pairs'. M2 is given for the 'nuclei of the two atoms', silicon and oxygen are referred to in the next sentence. Plurals were ignored, as were double bonds so the final sentence did not negate the mark. The marks could have been awarded for a correctly labelled diagram, but the candidates working here would not have scored.

ResultsPlus
Examiner Tip

Read the whole question carefully, the information in the question should help you get to the correct answer.

Question 21 (a)(ii)

Many candidates lost marks here as they assumed both compounds contained double bonds. The structure of silicon dioxide and the theory of orbital overlap may require more time in teaching, given that over half of candidates scored no marks for this question.

This is an example of a response that scored all 3 marks.

- In carbon dioxide there are 2 sigma bonds which is made by the head on overlapping of 2 orbitals. In addition ~~has~~ in the carbon dioxide molecule, it has a ~~double~~ ~~a~~ & one pi bond, located in the double bond between carbon and oxygen, which is caused by the overlapping of 2 p-orbitals.
- Silicon dioxide only has 2 sigma bonds.
- ∴, as carbon dioxide has a double bond, the covalent bonding between atoms is stronger compared to ~~SH~~ the covalent bonding in silicon dioxide.

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M1 is scored for the sigma bonds in both compounds. M2 is awarded for the description of sigma bonds as 'head-on overlapping'. M3 is awarded for the presence of a pi-bond in carbon dioxide. The comment about the strength of bonds was not required by this question.

ResultsPlus Examiner Tip

Try not to add unnecessary information to your answers. If it is incorrect it may cause you to lose marks.

This is an example of a correct response with suitable diagrams.

(ii) Compare and contrast the covalent bonding in carbon dioxide and silicon dioxide in terms of orbital overlap.

(3)

Carbon dioxide has head-to-head overlap of orbitals forming sigma bonds as well as sideways overlap of p orbitals forming 2 pi bonds. These π bonds ~~ae~~ are easier to break. Silicon dioxide contains sigma bonds of head-on-overlap of orbitals which are stronger.

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Examiner Comments

M2 and M3 could both be awarded from the diagrams here as the relevant bonds have been labelled. M1 is awarded as the sigma bonds in both compounds are mentioned in the text. M2 and M3 would also be awarded for the text alone in this response.

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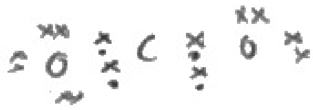
Examiner Tip

Diagrams can be a great way to communicate understanding – but make sure they are labelled.

This response contains common errors that led to only 1 mark being awarded.



Both silicone dioxide and carbon dioxide has two double covalent bonds. (O=S=O and O=C=O).

Silicon dioxide has 2 sigma bonds and 4 pi bonds.

Carbon dioxide also has 2 sigma bonds and 4 pi bonds.

A sigma bond is the bond resulting from the direct (linear) overlap of two s orbitals.

A pi bond is a bond resulting from the (lateral) overlap of two 'p' orbitals

ResultsPlus Examiner Comments

Neither dot-and-cross diagram is correct here but these would not have been sufficient for marks to be awarded even if correct. The mention of double / pi – bonds in silicon dioxide meant that M3 could not be awarded. M1 is awarded as the sigma bonds in both compounds are referenced. 'Direct (linear) overlap' is not sufficient for the awarding of M2.

ResultsPlus Examiner Tip

Sigma bonds should be described as 'end-on overlap'.

Pi bonds should be described as 'sideways overlap'.

Question 21 (b)(i)

The average mark for this question was just 1, usually awarded for the shape of the molecule and/or bond angle. Many candidates referred to bonding pairs rather than regions of electron density (but double bond electron pairs were accepted). Language was often imprecise when it came to the separation of the bonding atoms, but many candidates did not include this at all.

This is an example of a response scoring 3 marks.

(b) The shape of the carbon dioxide molecule affects its physical properties.

(i) Explain the shape of the carbon dioxide molecule.

(3)

Carbondioxide molecule has a linear shape with a bond angle of 180°.

It has 2 groups of bonded electron pairs, thus the atoms arrange in a ~~x~~ way to reduce the repulsion to the minimum.

ResultsPlus Examiner Comments

The first sentence scores M3. The '2 groups of bonded electron pairs' scores M1, though this could also have been awarded from the diagram. 'The atoms arrange in a way to reduce the repulsion to a minimum' is sufficient for M2.

NB The bond angle on the diagram is labelled incorrectly but this was ignored as both the bond angle and shape were correct above.

ResultsPlus Examiner Tip

A dot-and-cross diagram may help you work out the shape of a molecule but always draw a diagram with bonds shown as straight lines when representing shapes of molecules. Be careful to label bond angles correctly.

Question 21 (b)(ii)

Nearly half of candidates scored 0 on this question. A common reason for this was that some candidates quoted Pauling electronegativity values and incorrectly stated that there wasn't enough difference for the bond to be polar. Other candidates said there was a difference but didn't state which element was more electronegative.

This is an example of a common answer scoring 0.

(ii) Explain the polarity of the carbon–oxygen bond.

(2)

Carbon-oxygen bond is polar since each atom has a different electronegativity value so there is a difference in electronegativity thus the bond is polar.

ResultsPlus
Examiner Comments

The candidate has stated the bond is polar, but not given the element that is more electronegative or stated the partial charges of the elements. This means that no marks can be awarded.

ResultsPlus
Examiner Tip

Be specific when describing electronegativity differences – ensure you state which element is more electronegative.

This is an example of a response scoring 2 marks.

(ii) Explain the polarity of the carbon–oxygen bond.

(2)

since oxygen is more electronegative than carbon, it tends to attract the shared pair of electrons in the C-O bond. causing a partial negative charge on oxygen and partial positive charge on carbon, resulting in a polar bond

ResultsPlus
Examiner Comments

The candidate scores M2 on the first line. M1 is scored for the second sentence. The definition of electronegativity was not required or the clarification of the polar bond.

This is an example of a response scoring one mark.

(ii) Explain the polarity of the carbon–oxygen bond.

(2)

Carbon-oxygen band is a polar bond as oxygen has a higher electronegativity than carbon so $C^{\delta-}-O^{\delta+}$.

ResultsPlus
Examiner Comments

The candidate is awarded one mark for oxygen having a higher electronegativity (M2) but the delta positive and delta negative signs are the wrong way round on the carbon oxygen bond so it not awarded. This diagram, if correct, would have been sufficient for M1.

ResultsPlus
Examiner Tip

Double check your use of symbols – if an element is more electronegative it will be the delta negative atom in a bond.

Question 21 (b)(iii)

Over half of candidates did not score a mark here. Where candidates had misunderstanding in part bi or bii they often continued with the same incorrect reasoning into aiii. So where candidates thought the molecule was v-shaped they inevitably got this question wrong and no transferred error was awarded.

This is an example of where the candidate has achieved the mark.

(iii) State whether or not the carbon dioxide molecule is polar.
Justify your answer.

(1)

It is non-polar molecule as the shape of CO_2 is linear and symmetric leading to equal distribution of electrons around the molecule ~~so~~

ResultsPlus
Examiner Comments

The reference to symmetry scores the mark here.

This is an example of a candidate response that scored the mark.

(iii) State whether or not the carbon dioxide molecule is polar.
Justify your answer.

(1)

The carbon dioxide molecule has polar bonds. However, since it is a symmetrical molecule, dipoles cancel out. So, it is a non-polar molecule.

ResultsPlus
Examiner Comments

The candidate is awarded the mark for the reference to the molecule being symmetrical but could also be given for the dipoles cancelling out. It was also necessary for candidates to state that the molecule is non-polar in order to gain the mark.

ResultsPlus
Examiner Tip

Ensure you answer the question by rereading it after you have finished your response.

This is an example of where a candidate has continued their answer from bii into biii.

(iii) State whether or not the carbon dioxide molecule is polar.
Justify your answer.

(1)

Carbon dioxide is non polar, so as the electronegativity of charge difference between 2 points is same

ResultsPlus
Examiner Comments

The candidate has stated the molecule is non-polar but does not give a suitable justification so no mark is awarded.

ResultsPlus
Examiner Tip

Ensure your answers are legible so examiners can mark them easily.

This response does not contain sufficient detail for the mark to be awarded.

(iii) State whether or not the carbon dioxide molecule is polar.
Justify your answer.

(1)

It is not polar. As ~~there~~ both Oxygen atoms on both sides cancel out each others repulsion And hence no electronegativity difference.

ResultsPlus
Examiner Comments

Here the candidate has confused repulsion, electronegativity and polarity. This justification did not allow the mark to be awarded.

Question 21 (c)(i)

Many candidates did not achieve this mark, mainly due to the imprecision of their answers. The mark scheme required that candidates use the word tetrahedral to describe the structure as well as either the number of bonds formed around the silicon atoms or a reference to the structure as giant.

This is an example of a correct response.

(i) Using your knowledge of the structure of diamond, suggest how the structure of silicon dioxide is similar to that of diamond.

(1)

It has each silicon atom covalently bonded to 4 other oxygen atoms ; which gives it the giant structure and tetrahedral shape like that of diamonds.

ResultsPlus
Examiner Comments

The candidate has correctly identified the number of oxygen atoms each silicon is bonded to as well as stating it is a giant structure (either of these would have been sufficient for the mark, along with the 'tetrahedral shape').

ResultsPlus
Examiner Tip

Revise the different solid structures on the specification and identify for similarities and differences between them.

This is an example of a 'near miss'. The candidate has given a good answer but omitted a key word.

(i) Using your knowledge of the structure of diamond, suggest how the structure of silicon dioxide is similar to that of diamond.

(1)

They are both giant covalent structures. For diamond, each carbon atom can form 4 bonds with other carbon atoms. For silicon dioxide, each silicon atom can form 4 bonds with oxygen atoms.

ResultsPlus Examiner Comments

The candidate has written a reasonable answer but has not used the word 'tetrahedral' so the mark is not awarded. Where words are in bold in the mark scheme they are essential for an answer.

ResultsPlus Examiner Tip

Write a list of keywords to describe each type of solid structure when revising.

This is another example of a candidate not achieving the mark.

(i) Using your knowledge of the structure of diamond, suggest how the structure of silicon dioxide is similar to that of diamond.

(1)

Its a tetrahederal structure, diamond also forms a tetrahedral structure.

ResultsPlus
Examiner Comments

The candidate has used the word 'tetrahedral' twice but this answer lacks the detail required for the mark to be awarded.

ResultsPlus
Examiner Tip

Ensure you add sufficient detail to your answers.

Question 21 (c)(ii)

Many candidates did not achieve this mark but this was targeted at the top-end of the cohort. Where 'suggest' is used as a command word candidates are expected to bring together ideas from various parts of the specification and use their reasoning skills to formulate a suitable answer.

This an example of a good response that scores the mark.

(ii) Give a possible reason why silicon dioxide has a lower melting temperature than diamond, even though the Si—O bond is stronger than the C—C bond.

(1)

The O atoms are only bonded to 2 Si atoms, unlike how all C atoms are bonded to 4 more C atoms, so the structure is weaker.

ResultsPlus
Examiner Comments

Here the candidate has specified the number of bonds both the carbon and oxygen atoms form, giving a valid reason for the lower melting temperature.

This response scored a mark.

(ii) Give a possible reason why silicon dioxide has a lower melting temperature than diamond, even though the Si—O bond is stronger than the C—C bond.

(1)

- the C-C bonds are more than the Si-O bonds, which Makes it require an overall big amount heat Energy to break the many C-C bonds because being many, increases their total Surface Area.

ResultsPlus
Examiner Comments

The candidate has stated 'the C-C bonds are more than the Si-O bonds' and this was awarded the mark, the language is imprecise but the candidate further clarifies that there are many C-C bonds. The reference to total surface area is ignored.

ResultsPlus
Examiner Tip

Reread your answers to check they make sense.

Question 22 (a)

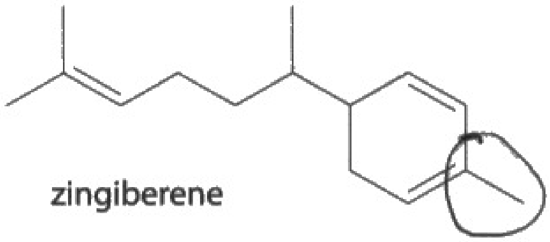
This question was poorly answered with many candidates circling either of the methyl groups on the hydrocarbon chain. Some circled both of the methyl groups at the end of the chain and a few even circled a double bond. Many of these diagrams were left blank so it is possible candidates did not realise that part a required a response. Often the diagram was annotated for counting the hydrogens and carbons for the molecular formula, even when no circle was seen. Candidates should know how to name and recognise parts of cyclic compounds as well as straight chains.

This response scored the mark.

22 Zingiberene is the compound that gives ginger its characteristic flavour.
Its IUPAC name is 2-methyl-5-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene.

(a) On the structure of zingiberene, draw a circle around the '2-methyl' group referred to in the IUPAC name.

(1)



zingiberene

ResultsPlus Examiner Comments

The inclusion of the '2' carbon was allowed and the mark was awarded here.

ResultsPlus Examiner Tip

Practise identifying each part of molecules with complicated names in lessons.

Question 22 (b)

One mark was most frequently awarded here, as candidates regularly miscounted both the number of carbon and hydrogen atoms. Many candidates used the diagram in order to count each atom but the mixture of double and single bonds added complexity to this question. A few shortened structural formulae were seen in responses.

No mark was awarded here.

(b) Deduce the molecular formula of zingiberene.

(2)

C_nH_{2n};

ResultsPlus
Examiner Comments

This candidate has given the general formula for an alkene. As this was not the molecular formula it did not score the mark and the candidate has failed to take into account the number of double bonds.

ResultsPlus
Examiner Tip

Practise writing molecular formulae for complex molecules.

An example of a fully correct response.

(b) Deduce the molecular formula of zingiberene.

(2)

$C_{15}H_{24}$

ResultsPlus
Examiner Comments

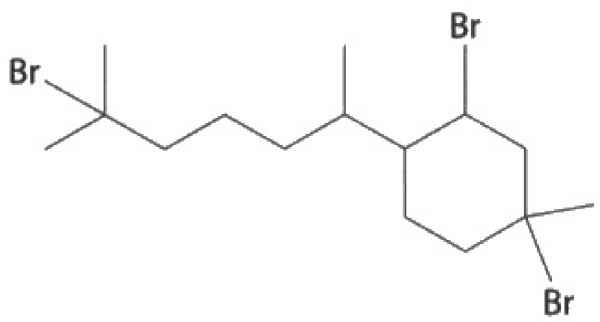
The candidate has correctly counted the number of carbon atoms and hydrogen atoms, taking into account the double bonds and cyclic section of the molecule.

Question 22 (c)(i)

Roughly half of candidates scored the mark here, which was less than expected. Many candidates just stated 'addition reaction' rather than giving the electrophilic mechanism name as well. Heterolytic was seen regularly, as were substitution and 'free radical'. Candidates need to revise the names and types of all the mechanisms thoroughly to ensure they can be precise in their answers.

This is an example of a common response that did not score.

(c) When zingiberene reacts with excess hydrogen bromide, there are a number of possible products. The structure of the major product is shown.



(i) Name the type and mechanism of the reaction.

(1)

Addition reaction (Hydrogen halide)

ResultsPlus
Examiner Comments

The candidate does not get the mark here as they have failed to name the mechanism. Both the type and the mechanism were required for the mark to be awarded.

ResultsPlus
Examiner Tip

Learn the names of all the reaction types and mechanisms on the specification.

Question 22 (c)(ii-iii)

There were six marks available here in two parts. The average mark for these responses was between two and three. Just over a quarter of candidates failed to score any marks and a disappointing number of blank answers were seen.

In the mechanism, the most frequent reasons for dropping marks included arrows not starting from the lone pair on the bromine, arrows going in the wrong direction and incorrect charges – these were sometimes full charges when they should have been partial and vice versa.

In part iii many candidates spoke of the compound being a tertiary or a carbocation. Many could state that a tertiary carbocation was more stable than a secondary, and secondary being more stable than primary was allowed.

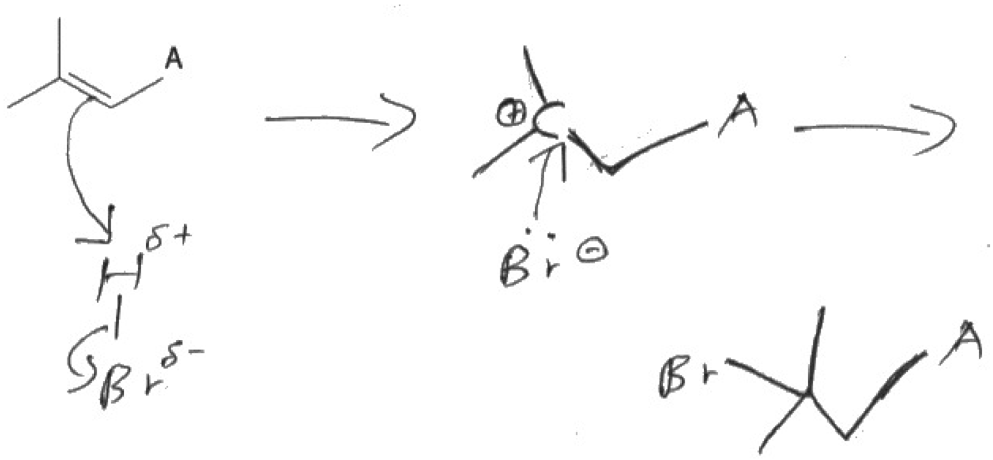
This response scores 4 for part ii and 2 for part iii.

(ii) The diagram shows a simplified structure of zingiberene, in which part of the molecule is represented by A.

Complete the mechanism for the reaction of zingiberene with **one** molecule of hydrogen bromide.

Include curly arrows, and any relevant dipoles and lone pairs.

(4)



(iii) For the reaction in (c)(ii) there are two possible products:

I II

Explain why I is the major product, by referring to your mechanism.

(2)

I compound has tertiary carbocation. It is more stable than secondary carbocation in compound II.

ResultsPlus
Examiner Comments

The mechanism here is correct for 4 marks. The dipole on the hydrogen bromide is correct and the arrow shows the movement of the electrons from the bond to the bromide ion. The arrow from the double bond to the delta positive hydrogen is also correct. The intermediate here is acceptable though it is unusual to show a carbon in the middle of a skeletal structure. The charge and lone pair are shown on the bromide and the arrow from the lone pair to the positive carbon gains the final mark.

The language isn't precise for part iii but was accepted as the meaning is clear, that in the mechanism compound I there is a tertiary carbocation while II has a secondary carbocation (M1). The statement about tertiary being more stable than secondary gains M2.

ResultsPlus
Examiner Tip

Precision is key in mechanisms, ensure your arrows start and end in the correct positions.

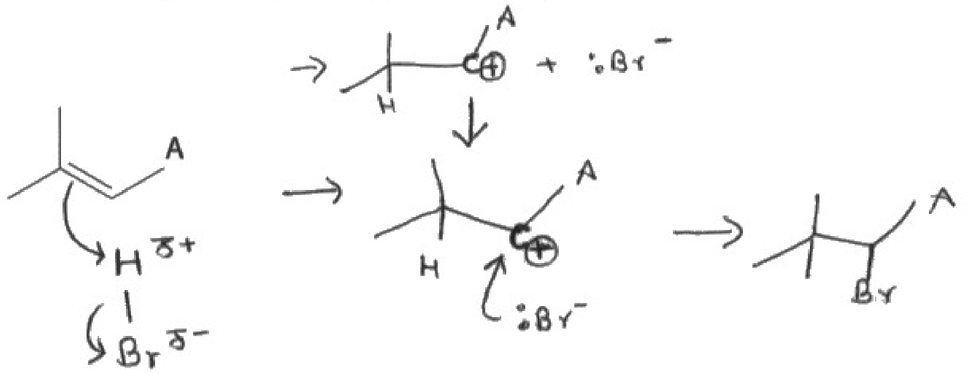
This is an alternative mechanism that also gains four marks. The second part shows a common mistake.

(ii) The diagram shows a simplified structure of zingiberene, in which part of the molecule is represented by A.

Complete the mechanism for the reaction of zingiberene with **one** molecule of hydrogen bromide.

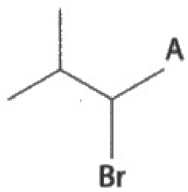
Include curly arrows, and any relevant dipoles and lone pairs.

(4)



(iii) For the reaction in (c)(ii) there are two possible products:

I



II

Explain why I is the major product, by referring to your mechanism.

(2)

This is because I is ~~secon~~ tertiary carbocation which is more stable than a secondary carbocation

ResultsPlus
Examiner Comments

The formation of a secondary carbocation was acceptable and all 4 marks were awarded here. Here, the arrow from the hydrogen bromide bond and the arrow from the bromide's lone pair are on the edge of acceptability and ideally they would start closer to each feature.

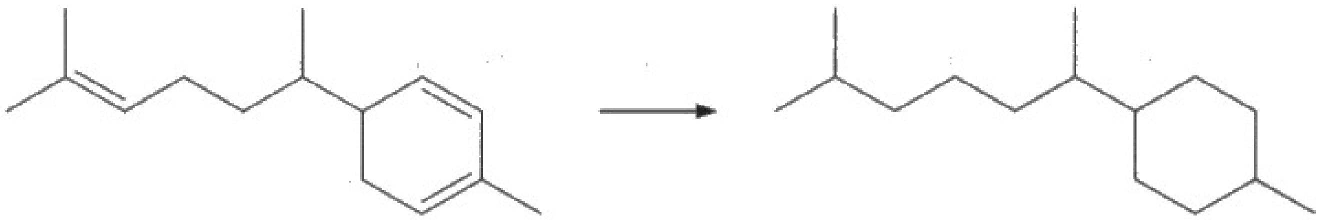
In part iii, compound I is described as a tertiary carbocation which is incorrect so M1 is not awarded. M2 is given for the tertiary carbocation being more stable than secondary.

Question 22 (d)(i)

Nearly two thirds of candidates could recall a catalyst for this reaction, with both nickel and platinum being accepted. However, some less able candidates gave a variety of acids and zeolite instead.

This is an example of a candidate giving more than one response to the question.

(d) Zingiberene reacts with hydrogen gas in the presence of a catalyst.



(i) Identify the catalyst, by name or formula.

(1)

Ni, Platinum, $KMnO_4$

ResultsPlus
Examiner Comments

This candidate has given the symbol for nickel and the name for platinum. Both of these are correct, however, they go on to give the formula of potassium manganate(VII) which is incorrect and negates the mark awarded.

ResultsPlus
Examiner Tip

Check the number of responses asked for each question, here 'the catalyst' indicates only one is required.

Question 22 (d)(ii)

The average mark here was 2 from the four. Many candidates lost marks as they did not realise that each mole of zingiberene would react with three moles of hydrogen. Some candidates also lost the final mark as they either did not give units or gave units inappropriate to their expression, the most common being dm^3 instead of m^3. M1 was the most frequently awarded mark with the vast majority of candidates being able to rearrange the expression.

This is an example of a common response.

(ii) 2.0 mol of zingiberene react completely with hydrogen at 150 °C and a pressure of 120 kPa.

Calculate the minimum volume of hydrogen needed under these conditions, stating your units.

[Ideal gas equation is $pV = nRT$ Gas constant (R) = 8.31 J mol^{-1} K^{-1}]

(4)

$pV = nRT$

$V = \frac{nRT}{P}$

$V = \frac{8.31 \times 2 \times 150+273}{120 \times 1000}$

$V = 0.059 \; dm^{-3}$

ResultsPlus
Examiner Comments

M1 is awarded for the rearranged ideal gas equation.

M2 is awarded for the conversion of the temperature to Kelvin and the pressure to Pascals.

M3 is not awarded as each mole of zingiberene will react with three moles of hydrogen, so the number of moles should be 6.

M4 is not awarded as the expression given would require the units of m^3.

ResultsPlus
Examiner Tip

Always check you are using the correct units for your answer.

This is an example of a fully correct response.

(ii) 2.0 mol of zingiberene react completely with hydrogen at 150 °C and a pressure of 120 kPa.

Calculate the minimum volume of hydrogen needed under these conditions, stating your units.

[Ideal gas equation is $pV = nRT$ Gas constant (R) = 8.31 J mol^{-1} K^{-1}]

(4)

zingiberene : hydrogen

1 : 3

2 : 6

$$V = \frac{nRT}{p}$$

$$V = \frac{6 \times 8.31 \times (150 + 273)}{120 \times 10^3}$$

$= 0.176\ m^3$

$= 175.8\ dm^3$

$= 176\ dm^3$

ResultsPlus
Examiner Comments

M1 is awarded for the rearrangement of the expression to give volume.

M2 is awarded for the conversion of temperature and pressure to the correct units.

M3 is awarded for the use of 6 moles of hydrogen.

M4 is awarded as the answer is correct and given with appropriate units (any of the three answers would have been given this mark, the use of 4 significant figures was not penalised here)

ResultsPlus
Examiner Tip

The clear layout of this calculation makes it very easy to mark.

Question 23 (a)(i)

Two thirds of candidates did not score this mark. Many candidates gave the answer of thermal decomposition which was not awarded. Some gave terms from the specification such as cracking, fractional distillation or combustion which were rather surprising.

This is an example of a response that scored credit.

23 Organic waste may be disposed of by landfill or incineration.
Both processes produce gases.

(a) The main gases produced from a typical landfill are shown in the table.

Gas	Percentage by volume / %
methane	50
carbon dioxide	45
nitrogen	4
sulfur compounds	1

(i) Name the process that forms these gases in landfill.

(1)

decomposition ~~fermentation~~

ResultsPlus
Examiner Comments

Decomposition was an allowed answer, as was fermentation if it hadn't been crossed out. The mark is awarded.

ResultsPlus
Examiner Tip

Only cross out your answers if you have written another.

This is an example of a response that did not score.

23 Organic waste may be disposed of by landfill or incineration.
Both processes produce gases.

(a) The main gases produced from a typical landfill are shown in the table.

CH_4

Gas	Percentage by volume / %
methane	50
carbon dioxide	45
nitrogen	4
sulfur compounds	1

(i) Name the process that forms these gases in landfill.

(1)

arobic respiration

ResultsPlus
Examiner Comments

Aerobic respiration is not an accepted answer, though anaerobic respiration would have been allowed.

Question 23 (a)(ii)

Almost half of candidates did not score this mark, though the majority of candidates did attempt this question. Many candidates gave more than one answer and this had the potential to negate any marks awarded.

This is an example of a fully correct answer.

(ii) State the **main** environmental problem caused by landfill gases, identifying the gas or gases responsible.

(2)

global warming by greenhouse gases, which are methane and carbon dioxide

ResultsPlus
Examiner Comments

Global warming was allowed for M1.

Both carbon dioxide and methane are given for M2.

This response did not score either mark.

(ii) State the **main** environmental problem caused by landfill gases, identifying the gas or gases responsible.

(2)

CO2, Sulfur dioxide, harmful gases to the environment.

ResultsPlus
Examiner Comments

'Harmful gases to the environment' is not sufficient for M1 to be awarded.

M2 is not awarded as methane is omitted and sulfur dioxide is included.

Question 23 (a)(iii)

Some blank responses were seen here and the average mark was one of the three available. M1 was the least frequently awarded as candidates regularly neglected to multiply by 45% and/or 365 to calculate the annual volume. M2 and M3 were more regularly awarded, though a minority of candidates multiplied by the molar gas volume and divided by the molar mass of carbon dioxide.

This is an example of a fully correct response.

(iii) One tonne of landfill waste produces approximately 12.5 dm^3 of landfill gases per day.

Calculate the mass of carbon dioxide produced in a year by a typical landfill site which contains 90 000 tonnes of waste.
Assume that the gas volume is measured at room temperature and pressure (r.t.p.). [Molar volume of gas at r.t.p. = 24.0 $dm^3 mol^{-1}$]

(3)

$90000 \times 12.5 \times 365$

$= 410625000$

$410625000 \times 45\%$

$= 184\,781250$ dm^3

$(184\,781250 / 24.0)(44)$

$= 338765625 (g)$

ResultsPlus
Examiner Comments

This candidate scores all three marks. The candidate has extracted the relevant numbers and information from the question and used them to good effect. The volume of carbon dioxide gas per year has been calculated for M1. This value has then be divided by the molar volume and multiplied by the molecular mass. The answer has been given with the correct units.

This is an example of a typical response worth two marks.

(iii) One tonne of landfill waste produces approximately 12.5 dm^3 of landfill gases per day.

Calculate the mass of carbon dioxide produced in a year by a typical landfill site which contains 90 000 tonnes of waste.
Assume that the gas volume is measured at room temperature and pressure (r.t.p.). [Molar volume of gas at r.t.p. = 24.0 $dm^3 mol^{-1}$]

(3)

1 tonne 12.5

90 000 ..... 1125000 dm^3 - landfill

$\frac{1125000}{24}$ = 46 875 mol

46 875 × (12+16+16) = 2 062 500

2062500g of CO_2

ResultsPlus
Examiner Comments

The candidate has not used all the information from the question to gain M1. They should have used the 45% from the table above and the number of days in a year to accurately calculate the volume of carbon dioxide released annually. M2 is awarded for the division by 24 to give the moles of carbon dioxide, as a transferred error. M3 is similarly awarded as a TE for the multiplication by 44 to give the mass of carbon dioxide.

ResultsPlus
Examiner Tip

Always check whether your answer requires units.

Question 23 (b)

This question was not well answered by candidates though many gave responses along the correct lines. The answers were often imprecise and lacking in detail. Candidates need to add more detail to their answers and ensure that they are using scientific terms accurately.

This is an example of a good quality response.

(b) Suggest **two** advantages of incineration over landfill.

(2)

Incineration can produce energy that can be used to produce electricity which can be used. Incineration does not take up a lot of space and land like landfill does and the waste products are completely broken down.

ResultsPlus
Examiner Comments

This candidate scores 2 marks for their response. The first mark is awarded for 'produce electricity'. The second mark is awarded for incineration using less space than landfill.

ResultsPlus
Examiner Tip

Ensure you always give the number of responses asked for in the question.

This is an example of a poor quality response.

(b) Suggest **two** advantages of incineration over landfill.

(2)

Incineration doesn't take up land and it can be used to produce energy locally.

ResultsPlus
Examiner Comments

No marks are awarded here. Incineration will take up land so no credit is given for this point. 'Produce energy' is also not sufficient for credit, as this is poor science (having no appreciation of the conservation of energy) and gives no indication of the type of energy that may be of use.

ResultsPlus
Examiner Tip

Be precise in your use of language and scientific principles.

Question 23 (c)

Over 80% of candidates were not awarded this mark. Many candidates gave a definition of recycling as their response, with limited reference to any chemistry.

This is an example of a common response that did not score the mark.

(c) Environmental groups prefer recycling to both landfill and incineration.

Suggest **one** advantage of recycling.

(1)

Recycling means that waste can be reused, and saves money by not having to create more of the product and doesn't affect the environment negatively.

ResultsPlus
Examiner Comments

This response is not specific enough to gain the mark, as it gives a definition of recycling and doesn't reference conserving resources, just money. 'Doesn't affect the environment negatively' is too vague to get credit.

ResultsPlus
Examiner Tip

Be specific in your answers, use key words and terms.

This is an example of a good response.

(c) Environmental groups prefer recycling to both landfill and incineration.

Suggest **one** advantage of recycling.

(1)

By recycling, we will decrease the mass of objects ~~goint~~ going to be disposed by landfill ~~and~~ or incineration so less greenhouse gases will be given out.

ResultsPlus
Examiner Comments

The mark is awarded for 'less greenhouse gases will be given out'. The candidate has refereed to both landfill and incineration in their answer showing that they fully understand the question.

This is an example of a response that gained credit.

(c) Environmental groups prefer recycling to both landfill and incineration.

Suggest **one** advantage of recycling.

(1)

* saving of raw materials
* less raw material being used
* decrease the pollution (recycling would be instead of cumbtion the garbage)

ResultsPlus
Examiner Comments

Either of the first two bullet points could have gained the mark. The final sentence on pollution is too vague to gain credit but was ignored.

Paper Summary

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

- Read the questions carefully, underlining or highlighting key words and using this to structure their answer.
- Record their answers for calculations to appropriate numbers of significant figures, using values stated in questions as a guide.
- Always give units with their answers.
- Practise deducing and drawing the reaction mechanisms on the specification, ensuring they are precise with their curly arrows.
- Practise interpreting and drawing mass spectra for different molecular ions.
- Revise knowledge that is expected from GCSE, such as balancing equations and state symbols.

Grade boundaries

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

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