OCR A-Level Chemistry A

Module 4: Core organic chemistry mark scheme · goes with “Module 4: Core organic chemistry” · whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/

Mark schemes

5 topics · 191 questions

Q1 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

Q2 · Alcohols and haloalkanes · [1 mark]

Answer: **D**

The C–I bond requires less energy to break than the C–Cl bond.

Q3 · Alcohols and haloalkanes · [12 marks]

OCR MARK SCHEME

6(a)

The –OH group is attached to a carbon that is attached to one hydrogen atom

OR

The –OH group is attached to a carbon that is attached to two C atoms/ alkyl groups/R groups ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW alcohol/ hydroxyl/functional group for –OH

6(b)

104.5° ✓

(oxygen atom) has two bond pairs and two lone pairs ✓

Bonded pairs/lone pairs/electron pairs repel ✓

Lone pairs repel more than bonding pairs ✓

***NOTE**: 'Lone pairs repel more than bonding pairs' would gain the last two marking points*

[4 marks]

ALLOW 104–105

ALLOW lp and bp

ALLOW bonding regions for bond pairs

***IGNORE** bonds repel / electrons repel*

***DO NOT ALLOW** atoms repel*

ALLOW alternative phrases/words to repel e.g. 'push apart'

6(c)(i)

Equation

$CH_3CH(OH)CH_2CH_3 + [O] \rightarrow CH_3COCH_2CH_3 + H_2O$ ✓

Structure of product could be allowed from equation

$CH_3COCH_2CH_3$ ✓

[2 marks]

ALLOW molecular formulae: $C_4H_{10}O$ and C_4H_8O

ALLOW C_4H_9OH

ALLOW C_2H_5 for CH_3CH_2

ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous

6(c)(ii)

Butan-2-ol/butanone is flammable

OR

Butan-2-ol/butanone is volatile/low boiling point

OR

Butan-2-ol /butanone will evaporate/boil away ✓

(Heat under) reflux OR a description of reflux with vertical condenser and a round bottomed or pear shaped flask with source of heat. ✓

[2 marks]

***IGNORE** vague answers about health and safety*

ALLOW alcohol for butan-2-ol

ALLOW ketone for butanone

***DO NOT ALLOW** the product or reactant.*

***DO NOT ALLOW** distillation*

***DO NOT ALLOW** any reference to closed system.*

6(d)

FIRST CHECK ANSWER ON THE ANSWER LINE

***IF** answer = 67.4% award all 3 marks for calculation*

n(butan-2-ol) $(\frac{m}{M})$

$= \frac{20.2}{74}$

OR

= 0.273 mol ✓

n(2-bromobutane $(\frac{m}{M})$

$= \frac{25.2}{136.9}$

OR

= 0.184 mol ✓

*If there is an alternative answer, check to see if there is any **ECF** credit possible*

ALLOW 3 SF: 0.273 up to calculator value of 0.272972973 correctly rounded

ALLOW 3 SF: 0.184 up to calculator value of 0.184075967 correctly rounded

ALLOW $\frac{25.2}{137} = 0.183941605$

ALLOW 67% if evidence shows 67.4% in answer

ALLOW 67.4% up to calculator value correctly rounded.

Common ECFs (2 marks)

Incorrect M_r resulting in incorrect moles of butan-2-ol or 2-bromobutane

% yield

$= \frac{0.184}{0.273} \times 100) = 67.4\%$ ✓

[3 marks]

ALLOW calculation in mass for 2nd and 3rd marks

$m(CH_3CHBrCH_2CH_3) = 0.273 \times 136.9 = 37.4$ g

% yield $= \frac{25.2}{37.4} \times 100 = 67.4\%$

Q4 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

pentan-3-ol

Q5 · Alcohols and haloalkanes · [11 marks]

OCR MARK SCHEME

4(a)

Displayed formulae of CH_3OH and H_2O

AND

C–O **AND** O–H polar bonds shown on CH_3OH molecule with δ+ and δ–

AND

Both O–H polar bonds shown on H_2O molecule with δ+ and δ– ✓

Two lone pairs shown on both oxygen atoms

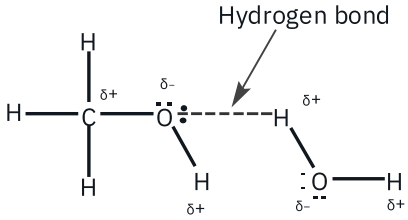
AND

Hydrogen bond/H-bond labelled and in the correct position between the H on water and the oxygen lone pair on methanol ✓

[2 marks]

EXAMINER GUIDANCE

Must be displayed formulae



IGNORE *δ+ shown on other H atoms*

ALLOW *hydrogen bond between the H on methanol (OH) and the oxygen lone pair on water*

4(b)(i)

3-methylbutan-2-ol ✓

[1 mark]

ALLOW *3-methyl-2-butanol*

ALLOW *3-methylbutane-2-ol*

ALLOW *absence of hyphens*

IGNORE *commas*

DO NOT ALLOW *2-methylbutan-3-ol*

4(b)(ii)

Peak X (m/z = 45)

CH_3CHOH^+ ✓

Peak Y (m/z = 88)

$CH_3CH(CH_3)CH(OH)CH_3^+$

OR

$CH_3CH(OH)CH(CH_3)_2^+$ ✓

[2 marks]

$C_5H_{12}O$ has lost C_3H_7

IGNORE $C_2H_5O^+$ ***OR*** $C_2H_4OH^+$ *ambiguous*

DO NOT ALLOW *unfeasible fragments*

e.g. $C_3H_9^+$ (too many H atoms)

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above for both structures*

IGNORE $C_5H_{12}O^+$

ALLOW $C_5H_{11}OH^+$

+ charge (anywhere on structure) required for each response

ALLOW *one mark if both formulae are correct but with no charge/incorrect charge*

ALLOW *one mark if both formulae are correct but incorrectly labelled X/Y*

4(c)

Level 3 (5-6 marks)

Indicative scientific points

1. Oxidation reaction forming aldehyde

A comprehensive explanation with all three scientific points covered thoroughly.

There is a well-developed description with a logical structure including correct chemical equations and an explanation with a clear line of reasoning including a fully labelled diagram.

Level 2 (3–4 marks)

The candidate attempts all three scientific points but explanations are incomplete.

OR

Explains two scientific points thoroughly with no omissions.

The description has a line of reasoning presented with some structure and includes correct structural formulae and an accurate diagram of a distillation apparatus.

Level 1 (1–2 marks)

A simple explanation based on at least two of the main scientific points

OR

The candidate explains one scientific point thoroughly with few omissions.

The description may be communicated in an unstructured way but it includes the correct reagents and conditions for the formation of the aldehyde.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks – No response or no response worthy of credit.

[6 marks]

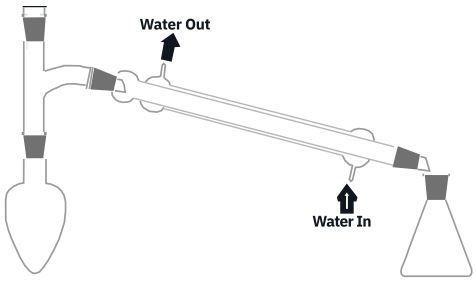
- acid/H^+ **AND** dichromate/$Cr_2O_7^{2-}$
- heat **AND** distillation
- organic product is butanal/$CH_3CH_2CH_2CHO$
- $CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO + H_2O$

2. Oxidation reaction forming carboxylic acid

- acid/H^+ **AND** dichromate/$Cr_2O_7^{2-}$
- heat under reflux
- organic product is butanoic acid/ $CH_3CH_2CH_2COOH$
- $CH_3CH_2CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2CH_2COOH + H_2O$

3. Distillation

- diagram of apparatus with condenser
- condenser has water flow
- collection of organic product
- product is separated to prevent further oxidation (to carboxylic acid)



Q6 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

Silver nitrate

Q7 · Alcohols and haloalkanes · [15 marks]

OCR MARK SCHEME

19(a)

$C_5H_{10}O + 7O_2 \rightarrow 5CO_2 + 5H_2O$ ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *multiples*

e.g. $2C_5H_{10}O + 14O_2 \rightarrow 10CO_2 + 10H_2O$

ALLOW *any equation involving an unsaturated alcohol with correct balancing*

e.g.

$C_5H_8O + 6.5O_2 \rightarrow 5CO_2 + 4H_2O$

$C_5H_6O + 6O_2 \rightarrow 5CO_2 + 3H_2O$

$C_5H_4O + 5.5O_2 \rightarrow 5CO_2 + 2H_2O$

$C_5H_2O + 5O_2 \rightarrow 5CO_2 + H_2O$

IGNORE *state symbols*

19(b)(i)

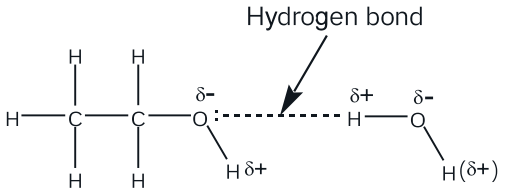
Diagram showing a water molecule and an ethanol molecule with at least one $H^{\delta+}$ and one $O^{\delta-}$ on BOTH molecules ✓

Hydrogen bond between one lone pair on O atom in one of the molecules and the H atom of another.

AND

Hydrogen bonding stated or labelled on diagram ✓

e.g.



[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

DO NOT ALLOW *δ+ on H atoms of alkyl group*

DO NOT ALLOW *any marks for a diagram containing* O_2H

If more than one hydrogen bond is shown they must all be correct to award the mark.

19(b)(ii)

Hexane-1,6-diol has more OH groups (than hexan-1-ol)

AND

(hexane-1,6-diol) forms more hydrogen bonds with water ✓

[1 mark]

Statements MUST be comparative

e.g. hexane-1,6-diol has two –OH groups and hexan-1-ol has one -OH group

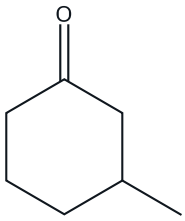
ALLOW *hydroxyl or hydroxy*

DO NOT ALLOW *hydroxide/*OH^-

ALLOW ORA

19(c)(i)

Starting material from reduction reaction



✓

Reagent for reduction

$NaBH_4$ ✓

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Watch for missing methyl groups

IGNORE H^+ */ acid or* H_2O *or ethanol*

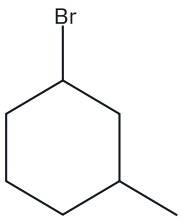
ALLOW *sodium borohydride*

OR sodium tetrahydridoborate

ALLOW $LiAlH_4$

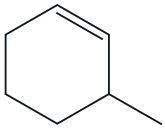
ALLOW *in either order*

Product from reaction with $NaBr/H_2SO_4$



✓

Structural isomers



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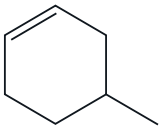


✓

[5 marks]

19(c)(ii)

3-methylcyclohexanol ✓

[1 mark]

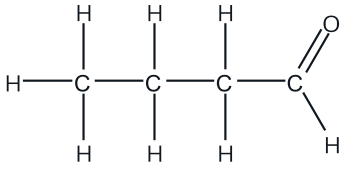
ALLOW *3-methylcyclohexan-1-ol*

ALLOW *1-methylcyclohexan-3-ol*

IGNORE *lack of hyphens, or addition of commas*

19(d)

Structures of organic products



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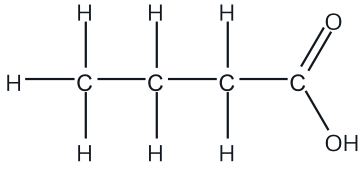


✓

Equations

$CH_3CH_2CH_2CH_2OH + [O] \rightarrow CH_3CH_2CH_2CHO + H_2O$ ✓

$CH_3CH_2CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2CH_2COOH + H_2O$ ✓

Reaction conditions

Distillation to produce aldehyde/$CH_3CH_2CH_2CHO$

AND

Reflux to produce carboxylic acid/$CH_3CH_2CH_2COOH$ ✓

Use of any primary alcohol containing 3, 5 or more carbons can be awarded up to 4 marks.

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

IGNORE *names*

DO NOT ALLOW *$CH_3CH_2CH_2COH$ for the structure of the aldehyde.*

ALLOW *$CH_3CH_2CH_2CO_2H$ for the structure of the carboxylic acid.*

ALLOW *marks for structures from equations as long as unambiguous.*

ALLOW *molecular formulae in equations*

e.g. $C_4H_{10}O + [O] \rightarrow C_4H_8O + H_2O$

$C_4H_{10}O + 2[O] \rightarrow C_4H_8O_2 + H_2O$

$C_4H_9OH + [O] \rightarrow C_3H_7CHO + H_2O$

$C_4H_9OH + 2[O] \rightarrow C_3H_7CO_2H + H_2O$

IGNORE *incorrect structures in equations*

i.e. $C_4H_{10}O + [O] \rightarrow C_3H_7COH + H_2O$ scores equation mark

Conditions must be linked to aldehyde/carboxylic acid or correct products.

[5 marks]

Conditions may be written above arrow of equation.

Q8 · Alcohols and haloalkanes · [1 mark]

Answer: **C**

OCR MARK SCHEME

3

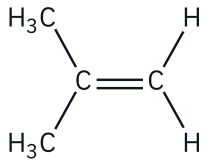
EXAMINER GUIDANCE

ALLOW *3*

Q9 · Alcohols and haloalkanes · [9 marks]

OCR MARK SCHEME

25(a)(i)



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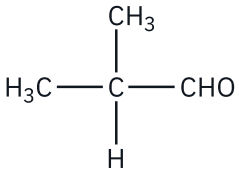

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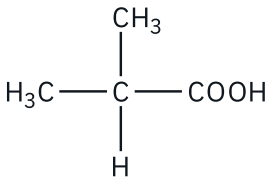


H

✓

[3 marks]

EXAMINER GUIDANCE

ALLOW *correct structural* ***OR*** *displayed*

OR skeletal formulae **OR** mixture of the above (as long as unambiguous)

IGNORE *molecular formula*

ALLOW *CH_3–*

ALLOW *1 mark for* ***G AND H*** *combined if structures are correct but in wrong boxes*

25(a)(ii)

2-methylpropan-1-ol ✓

Both numbers required

[1 mark]

IGNORE *absence of hyphen or use of dots or commas as separators*

DO NOT ALLOW *2-methylprop-1-ol*

OR 2-methpropan-1-ol

OR 2-methypropan-1-ol

25(b)(i)

Curly arrows 2 marks

curly arrow from OH^- to C atom of C–Br bond ✓

dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

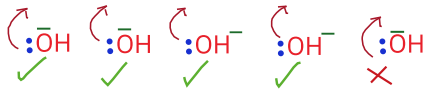
AND curly arrow from C–Br bond to Br atom ✓

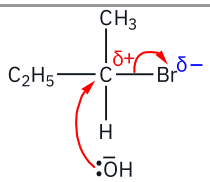
1st curly arrow must

- go to the C of C–Br

AND

- start from, **OR** be traced back to any point across width of lone pair on O of OH^-





IGNORE *incorrect R groups for curly arrow marks*

IGNORE *presence of Na^+/Na but OH^- needed*

i.e. Na^+OH^-; $NaOH^-$ can be allowed with correct use of curly arrow

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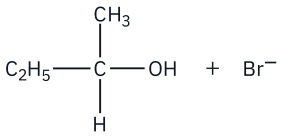
Products 1 mark

correct organic product **AND** Br^- ✓



IGNORE *presence of Na^+ but Br^- needed*

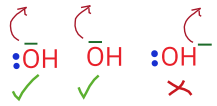
i.e. Na^+Br^-/$NaBr^-$ can be allowed

BUT NaBr does **NOT** show Br^-

NOTE*: curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

[3 marks]

- **OR** start from – charge on O of ^-OH ion



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, **OR** be traced back to, any part of C–Br bond and go to Br

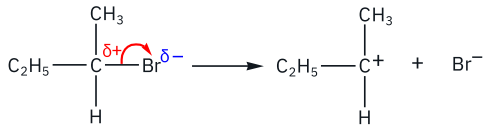


ALLOW *S_N1 mechanism for 2 curly arrow marks*

First mark

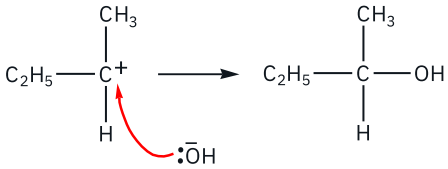
Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

AND curly arrow from C–Br bond to Br atom ✓



Second mark

Curly arrow from OH^- **AND** to correct carbocation



Use curly arrow criteria in guidance above

25(b)(ii)

Disappearance of peak at 500–800 cm^{-1} **OR** C–Br peak ✓

Appearance of peak at 3200–3600 cm^{-1} **OR alcohol** O–H peak ✓

[2 marks]

ALLOW *value within range 500–800 cm^{-1}*

ALLOW *value within range 3200–3600 cm^{-1}*

DO NOT ALLOW *responses that only describe the spectrum shown*

Q10 · Alcohols and haloalkanes · [11 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

16(a)(i)

3-methylbutan-2-ol ✓

[1 mark]

IGNORE *lack of hyphens or addition of commas*

ALLOW *3-methylbutane-2-ol*

DO NOT ALLOW *2-methylbutan-3-ol*

OR 3-methylbut-2-ol

OR 3-methbutan-2-ol

OR 3-methybutan-2-ol

OR 3-methlybutan-2-ol

16(a)(ii)

$(CH_3)_2CHCHOHCH_3$ ✓

ALLOW *brackets around OH*

e.g. $(CH_3)_2CHCH(OH)CH_3$

[1 mark]

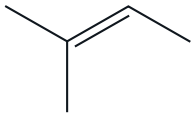
ALLOW *any unambiguous structural formula*

e.g. $CH_3CH(CH_3)CHOHCH_3$

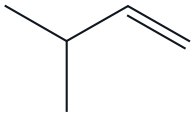
$CH_3CH(CH_3)CH(CH_3)OH$

16(a)(iii)

One mark for each correct structure.



✓



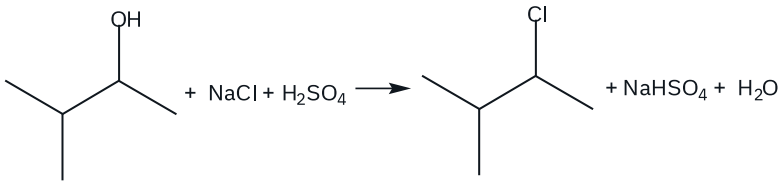
✓

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *in either order*

[2 marks]

16(a)(iv)



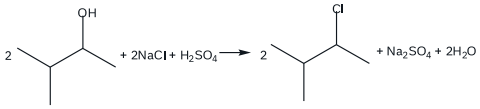
Correct haloalkane ✓

Correctly balanced equation ✓

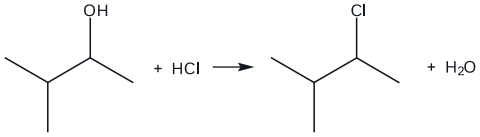
ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *H^+ for H_2SO_4*

ALLOW *equations forming Na_2SO_4*



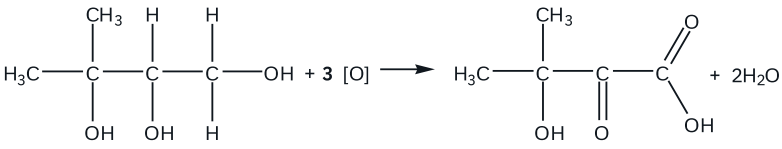
ALLOW *equations with HCl*



DO NOT ALLOW *equations that form NaOH*

[2 marks]

16(b)



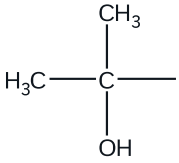
Correct organic product ✓

Rest of equation ✓

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

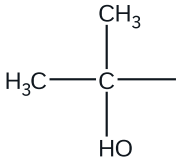
ALLOW *any vertical bond to the tertiary OH group*

e.g. **ALLOW**



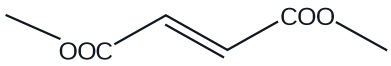
OR

[2 marks]



ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

e.g



IGNORE *connectivity in each product*

ALLOW *the E or Z isomer as product from excess* CH_3OH/H_2SO_4

'End bonds' MUST be shown (do not have to be dotted)

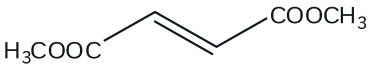
IGNORE *brackets*

IGNORE *n*

ALLOW *more than one repeat unit but has to be a whole number of repeat units*

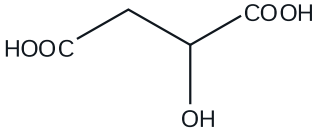
16(c)

Product from excess CH_3OH/H_2SO_4



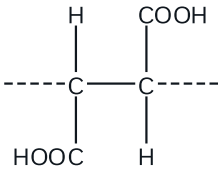
✓

Product from steam, H_3PO_4

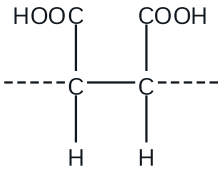


✓

Repeat unit of polymer C



OR



✓

[3 marks]

Q11 · Alcohols and haloalkanes · [10 marks]

OCR MARK SCHEME

19(a)

Links rate of reaction to strength of bond/bond enthalpy ✓

e.g.

the weaker the bond the faster the reaction

stronger bond takes longer to break

lower bond enthalpy reacts faster

Correct comparison of rate of reaction for at least two C–Hal bonds

e.g.

C–F bond is hydrolysed slowest

C–I bond is hydrolysed faster than C–Br

C–Br has shorter reaction time than C–Cl

OR

EXAMINER GUIDANCE

Each marking point must be a comparison

IGNORE *references to halogens as elements:*

i.e. chlorine is less reactive than bromine etc.

DO NOT ALLOW *chloride, bromide and iodide*

IGNORE *references to bond length, polarity and electronegativity*

Correct comparison of C–Hal bond strength/enthalpy of at least two of C–Hal bonds

e.g.

C–I bond is the weakest

C–I has lower bond enthalpy than C–Br

C–Br is broken more easily/readily than C–Cl

C–Hal bond strength decreases down group (7) ✓

[2 marks]

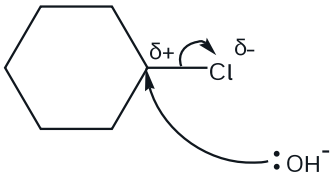
19(b)

Curly arrow from HO^- to carbon atom of C–Cl bond ✓

Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$

AND

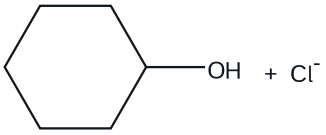
curly arrow from C–Cl bond to Cl atom ✓



IGNORE *presence of Na^+ but OH^- needed*

i.e. Na^+OH^- can be allowed if criteria met

Correct organic product **AND** Cl^- ✓



IGNORE *presence of Na^+ but Cl^- needed*

i.e. Na^+Cl^- can be allowed

BUT NaCl does **NOT** show Cl^-

[3 marks]

NOTE*: curly arrows can be straight, snake-like, etc.*

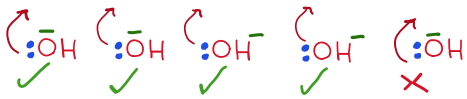
but **NOT** double headed or half headed arrows

1st curly arrow must

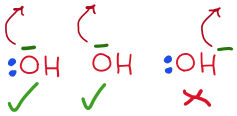
- go to the C of C–Cl

AND

- start from, **OR** be traced back to any point across width of lone pair on O of OH^-

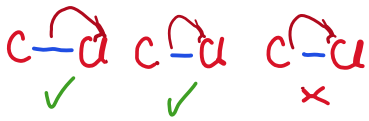


- **OR** start from – charge on O of ^-OH ion



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, **OR** be traced back to, any part of C–Cl bond and go to Cl

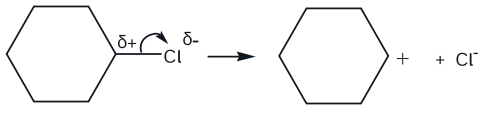


ALLOW *S_N1 mechanism*

First mark

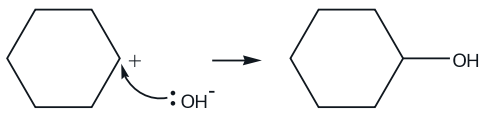
Dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$,

AND curly arrow from C–Cl bond to Cl atom ✓



Second mark

Correct carbocation **AND** curly arrow from HO^- to carbocation



Curly arrow must come from lone pair on O of HO^- **OR** OH^-

OR from minus on O of HO^- ion (no need to show lone pair if curly came from negative charge) ✓

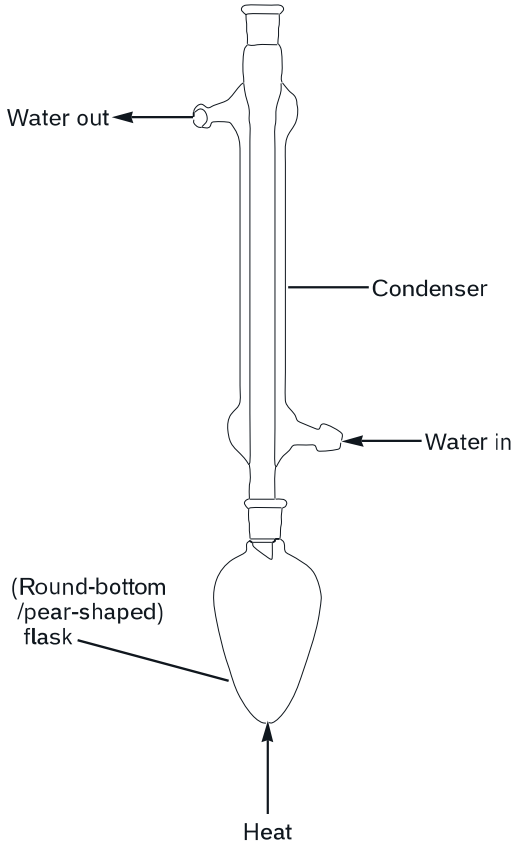
Third mark

Correct organic product **AND** Cl^- ✓

19(c)(i)

Diagram

Diagram showing round bottom/pear shaped flask **AND** upright condenser ✓



DO NOT ALLOW *conical flask, volumetric flask, beaker in place of round bottom/pear shaped flask*

DO NOT ALLOW *distillation*

DO NOT ALLOW *stopper/bung on top of condenser*

IGNORE *a thermometer in condenser*

IGNORE *a small gap between flask and condenser*

ALLOW *diagram of heating apparatus as an alternative to heat label*

Labels

(Round-bottom/pear-shaped) flask

AND condenser

AND water in at bottom and out at top

AND heat (source) ✓

[2 marks]

19(c)(ii)

Precipitate G 1 mark

silver bromide/AgBr

AND

$M = \dfrac{1.88}{0.01} = 188\ (g\ mol^{-1})$

188 – 107.9 = 80.1 (so halide is Br^-) ✓

Alcohol F and Haloalkane E 2 marks

E and F clearly identified

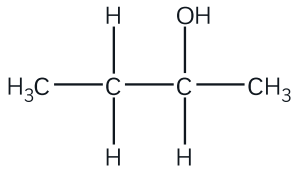
ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Note: working is required for first mark

ALLOW *use of 108 as* A_r *of Ag*

Note: E and F can be identified by correct name or structure ***BUT IGNORE*** *incorrect names*

F/alcohol: butan-2-ol



E/haloalkane:

E is haloalkane of C_4H_9X with

- same halogen as G

AND

- same carbon chain as F ✓

[3 marks]

Q12 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

CH_3CHCH_2

Q13 · Alcohols and haloalkanes · [1 mark]

Answer: **D**

$NO_2 + O \rightarrow NO + O_2$

Q14 · Alcohols and haloalkanes · [12 marks]

OCR MARK SCHEME

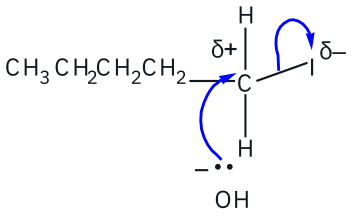
3(a)(i)

Curly arrow from HO^- to carbon atom of C–I bond ✓

Dipole shown on C–I bond, $C^{\delta+}$ and $I^{\delta-}$

AND

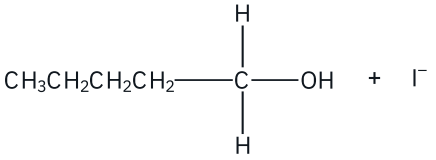
curly arrow from C–I bond to I atom ✓



IGNORE *presence of* Na^+ *but* OH^- *needed*

i.e. Na^+OH^- can be allowed if the criteria are met

Correct organic product AND I^- ✓



IGNORE *presence of* Na^+ *but* I^- *needed*

i.e. Na^+I^- can be allowed BUT NaI does not show I^-

[3 marks]

EXAMINER GUIDANCE

NOTE*: curly arrows can be straight, snake-like, etc.*

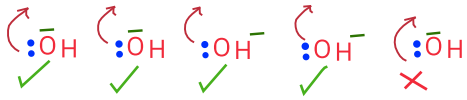
but **NOT** double headed or half headed arrows

1st curly arrow must

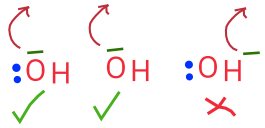
- go to the C of C–I

AND

- start from, **OR** be traced back to any point across width of lone pair on O of OH^-



- **OR** start from – charge on O of ^-OH ion



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, **OR** be traced back to, any part of C–I bond and go to I



3(a)(ii)

Time for precipitate to appear ✓

[1 mark]

Time AND precipitate required

Question asks for measurement

3(a)(iii)

C–I bond is weaker (than C–Br bond)

OR

C–I bond has a lower bond enthalpy (than C–Br bond) ✓

Carbon – halogen bond breaks ✓

[2 marks]

For 2 marks,

ALLOW *C–I is broken more easily (than C–Br) as the bond is weaker*

There must be a comparison between C–Br and C–I bonds

3(b)(i)

Molecular mass ✓

[1 mark]

IGNORE *'relative'*

IGNORE *'molecular ion' alone, answer must relate to mass*

ALLOW *M_r / molar mass*

3(b)(ii)

Y: $CH_3CH_2CH_2CH_2CH_2^+$ ✓

Z: $CH_3CH_2CH_2^+$ ✓

If positive charge is missing but the structures of Y AND Z are correct, award one mark

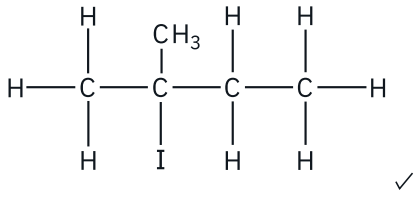
[2 marks]

FOR ONE MARK

ALLOW *$C_5H_{11}^+$ AND $C_3H_7^+$*

ALLOW *any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

3(c)(i)



[1 mark]

ALLOW *any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

3(c)(ii)

Similarity

Both have a peak at (m/z =) 198 (X) **OR** 71 (Y) **OR** 29 ✓

Difference

2-iodo-2-methylbutane has no peak at (m/z =) 43 (Z) ✓

[2 marks]

ALLOW *same molecular ion peak / M_r*

IGNORE *statements where no specific ion peak is suggested e.g. "different ion peaks"*

Q15 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

Q16 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

The C–Br bond enthalpy is less than the C–Cl bond enthalpy.

Q17 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

RBr is hydrolysed faster because the C–Cl bond enthalpy is greater than C–Br.

Q18 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

1, 2 and 3

Q19 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

Ultraviolet radiation can cause some polymers to photodegrade to benefit the environment.

Q20 · Alcohols and haloalkanes · [10 marks]

OCR MARK SCHEME

3(a)

Level 3 (5–6 marks)

Diagram showing reflux with most labels

AND

A CORRECT calculation of the % yield of 1-bromobutane

AND

A detailed description of most purification steps.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Diagram showing reflux with some labels

AND

Calculates the % yield of 1-bromobutane with some errors

OR

Diagram showing reflux with most labels

AND

describes some purification steps, with some detail

OR

Calculates the % yield of 1-bromobutane with some errors

AND

describes some purification steps, with some detail

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Diagram showing reflux

OR

Attempts to calculate the % yield of 1-bromobutane

OR

Describes few purification steps.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

EXAMINER GUIDANCE

Indicative scientific points may include:

Diagram

Diagram draw with condenser above flask

Labels including

- condenser
- water in at bottom and out at top
- pear-shaped or round-bottom flask

Calculation of % yield of 1-bromobutane

- n(butan-1-ol) = $\frac{9.25}{74.0}$ = 0.125 (mol)
- mass 1-bromobutane = 6.10 × 1.268 = 7.7348 g
- n(1-bromobutane) = $\frac{7.7348}{136.9}$ = 0.0565 (mol)
- % yield = $\frac{0.0565}{0.125}$ × 100 = 45.2%

ALLOW *45.2 ± 0.2 for small slip/rounding*

NOTE Use of 6.1 g (omission of density)

- n(1-bromobutane) = $\frac{6.10}{136.9}$ = 0.044558... (mol)
- % yield = $\frac{0.044558...}{0.125}$ × 100 = 35.6%

Purification

- In separating funnel, **organic layer is on bottom**
- Drying with an **anhydrous salt by formula or name**, e.g. $MgSO_4$, Na_2SO_4, $CaCl_2$
- Redistil **at 102°C**

Examples of detail in **bold** (**NOT INCLUSIVE**)

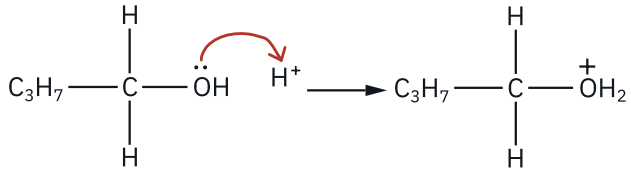
[6 marks]

3(b)

Step 1 The oxygen atom of the alcohol group accepts a proton to form a positively-charged intermediate.

2 marks

Curly arrow ✓



Intermediate ✓

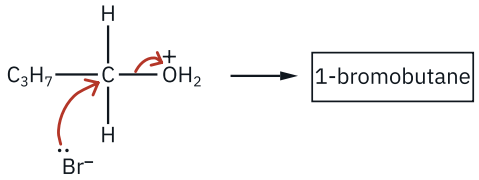
Step 2 Bromide ions react with the intermediate by nucleophilic substitution to form 1-bromobutane.

2 marks

2 possible routes:

EITHER

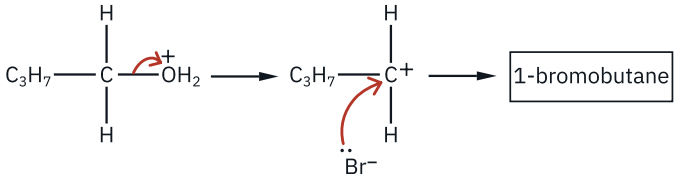
Curly arrow ✓



Curly arrow ✓

OR

Curly arrow ✓



Curly arrow ✓

[4 marks]

***NOTE**: 'Use a separating funnel', dry, and 'redistil' on their own are **NOT** detailed descriptions*

***ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

For $CH_3CH_2CH_2$, **ALLOW** $CH_3(CH_2)_2$, C_3H_7

***IGNORE** dipoles*

***ALLOW** curly arrow to H of H–O–SO_3H **OR** H–Br*

***IGNORE** absence of curly arrow from H–O or from H–Br*

+ charge MUST be on O of intermediate

Curly arrow must

- start from, **OR** be traced back to any point across width of lone pair on :Br^- **OR** :OH **OR** start from – charge on Br^-

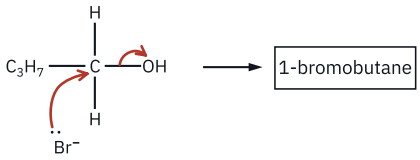
(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)

***IGNORE** final products: 1-bromobutane and H_2O*

***IF** $C_3H_7CH_2–O^+H_2$ is not shown, **ALLOW** intermediate mark for carbocation: $C_3H_7CH_2^+$*

***ALLOW** 2 marks max for mechanism without positively charge intermediate, i.e.*

Curly arrow ✓



Curly arrow ✓

Q21 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

Q22 · Alcohols and haloalkanes · [5 marks]

OCR MARK SCHEME

26

Correct structural isomers of C_3H_8O 1 mark

$CH_3CH_2CH_2OH$ AND $CH_3CHOHCH_3$ ✓

Reaction conditions 1 mark

Distillation for aldehyde

EXAMINER GUIDANCE

Throughout,

***ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

*IF functional group is **NOT** given,*

***ALLOW** propanal / RCHO*

AND reflux for carboxylic acid **OR** ketone ✓

Functional group of organic product 2 marks

$CH_3CH_2CH_2OH$ → aldehyde

OR → carboxylic acid ✓

$CH_3CHOHCH_3$ → ketone ✓

One correct equation 1 mark

$CH_3CH_2CH_2OH + [O] \rightarrow CH_3CH_2CHO + H_2O$

OR

$CH_3CHOHCH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$

OR

$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$ ✓

ALLOW *propanoic acid / RCOOH*

ALLOW *propanone / ….. RCOR*

IGNORE *small slips in formulae (assessed in equation)*

[5 marks]

Q23 · Alcohols and haloalkanes · [15 marks]

OCR MARK SCHEME

3(a)

Level 3 (5–6 marks)

A comprehensive explanation of relative reactivities of chlorine and iodine

AND

Uses an appropriate method to calculate volume of seawater allowing for an acceptable error

There is a well-developed line of reasoning which is clear an d logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

A comprehensive explanation of relative reactivities of chlorine and iodine

AND

Some attempt at calculation

OR

Explanation of relative reactivities of chlorine and iodine containing most details

AND

A reasonable attempt at calculation

OR

Explanation of relative reactivities of chlorine and iodine containing some details

AND

Uses an appropriate method to calculate volume of seawater allowing for an acceptable error

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Explanation of relative reactivities of chlorine and iodine containing some details

AND

Some attempt at the calculation

OR

Explanation of relative reactivities containing most details

EXAMINER GUIDANCE

Indicative scientific points may include:

Explanation of relative reactivities

Comparison required throughout

- Chlorine gains electron more easily

OR forms negative ion more easily

OR attracts an electron (to its outer shell) more easily

- Because chlorine (atom) is smaller

OR outer shell of chlorine less shielded/closer

- Greater nuclear attraction (on chlorine electrons)
- **ORA**

IGNORE 'nuclear charge' for 'nuclear attraction'

Determination of volume of seawater

- $Cl_2(g) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$

OR molar ratio I^-: I_2 = 2:1

- $n(I_2) = \frac{1 \times 10^6}{253.8}$ = 3940(.11…) (mol)
- n(KI) = 3940(.11…) × 2 = 7880.(22…) (mol)
- n(KI) in 1 dm^3 seawater = $\frac{0.150}{166}$

= 9.036(144..) × 10^{-4} (mol)

- Volume of seawater = $\frac{7880.(22..)}{9.036(...) \times 10^{-4}}$

=8.72…… × 10^6 dm^3

Alternative method:

- m(KI) = 7880.(22…) x 166 (mol)

= 1.308(116627) x 10^6

OR

A reasonable attempt at calculation

The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.

0 marks

No response or no response worthy of credit.

[6 marks]

- Volume of seawater

$$= \frac{1.308(116627)\ x 10^6}{0.15}$$

$=8.72..... \times 10^6\ dm^3$

Acceptable errors:

Volume of seawater obtained from:

- Use of 126.9 to find $n(I_2)$ giving $1.74....x\ 10^7$
- Missing x 2 ratio giving $4.36....x\ 10^6$

DO NOT ALLOW *for L3 if both errors are present, please note it gives a volume of* $8.72..... \times 10^6\ dm^3$

ALLOW *minor slips in rounding, transcription errors, etc throughout*

3(b)

Disproportionation

Oxidation AND reduction of same element/chlorine

OR

Chlorine/Cl/Cl_2 has been oxidised AND chlorine/Cl/Cl_2 has been reduced ✓

IGNORE numbers around equation for oxidation numbers

IGNORE 'species' or 'reactant' for element

ALLOW *1+ for +1 AND 1– for –1*

Oxidation

from 0 in Cl_2 to +1 in $Ca(OCl)_2$ OR ClO^- ✓

NOTE for chlorine/Cl_2 from 0 only needs to be seen once, does not need to be stated twice

Reduction

from 0 in Cl_2 to –1 in $CaCl_2$ OR Cl^- ✓

ALLOW *1 mark for 3 oxidation numbers correct but no mention of words oxidation/reduction: e.g.*

0 in Cl_2 AND –1 in $CaCl_2$ AND +1 in $Ca(OCl)_2$

ALLOW *1 mark for species missing*

oxidised from 0 to +1

AND reduced (from 0) to –1

[3 marks]

3(c)

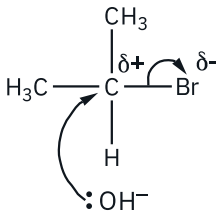
Mechanism

Curly arrow from OH^- to C atom of C–Br bond in 2-bromopropane ✓

Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

AND

curly arrow from C–Br bond to Br atom ✓

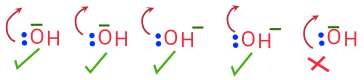


1st curly arrow must

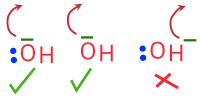
- go to the C of C–Br

AND

- start from, OR be traced back to any point across width of lone pair on O of OH^-



- OR start from – charge on O of ^-OH ion



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, OR be traced back to, any part of C–Br bond and go to Br



Name

nucleophilic substitution ✓

NOTE*: Curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

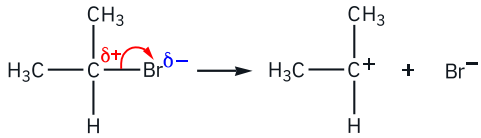
[3 marks]

ALLOW *S_N1 mechanism for 2 curly arrow marks*

First mark

Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

AND curly arrow from C–Br bond to Br atom ✓



Second mark

Curly arrow from OH^- AND to correct carbocation ✓

Curly arrow must come from lone pair on O of HO^- OR OH^- OR from minus on O of HO^- ion (no need to show lone pair if curly came from negative charge) ✓

3(d)(i)

ALLOW *1 mark if correct formula for both OR correct colour for both*

Shaded cells were given in the question.

Haloalkane	Formula	Colour
2-bromopropane	AgBr	cream ✓
2-iodopropane	AgI	yellow ✓

Formula AND colour required for each mark

[2 marks]

3(d)(ii)

AgI OR yellow (precipitate forms first)

AND

C–I bond is weaker (than C–Br bond) ✓

[1 mark]

ALLOW *(precipitate from) 2-iodopropane*

ALLOW ECF from incorrect formula or colour ppt from 3(d)(ii)

ALLOW *C–I bond has a lower bond enthalpy*

OR C–I bond is longer

ORA

IGNORE references to bond length, polarity and electronegativity

Q24 · Alcohols and haloalkanes · [14 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

17(a)

$C_6H_{11}OH$ ✓

Correct balanced equation

$C_6H_{11}OH + 8½\ O_2 \rightarrow 6CO_2 + 6H_2O$ ✓

[2 marks]

For $C_6H_{11}OH$, **ALLOW** $C_6H_{12}O$ OR any combination of skeletal OR structural OR displayed formula

ALLOW *multiples*

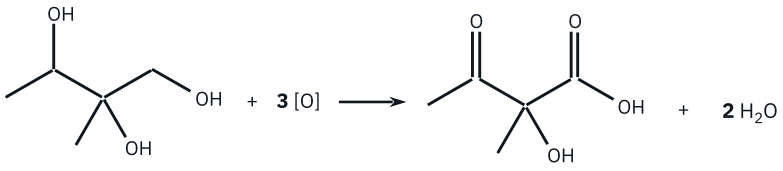
IGNORE *state symbols*

ALLOW *multiple OH groups in structure for both marks e.g.*

$C_6H_{12}O_2$ ✓

$C_6H_{12}O_2 + 8O_2 \rightarrow 6CO_2 + 6H_2O$ ✓

17(b)



Compound C

Correct organic product ✓✓

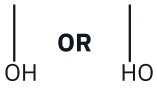
Correct balanced equation ✓

[3 marks]

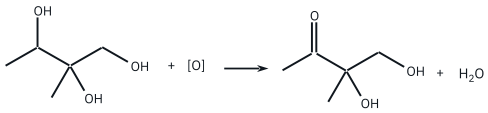
ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

ALLOW *any vertical bond to the OH group*

e.g. **ALLOW**



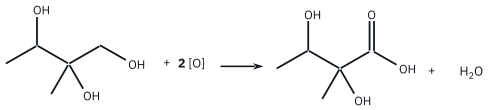
ALLOW *1 mark for partially oxidised organic product and an additional mark for ECF for correct balanced equation for this product. i.e.*



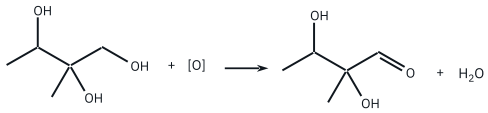
Organic product ✓

Correct balanced equation ✓

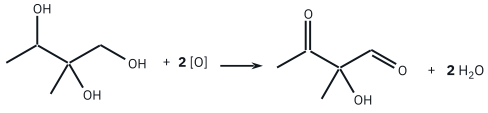
OR



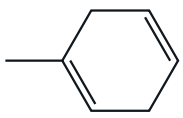
OR



OR

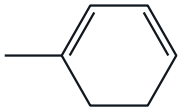


17(c)(i)

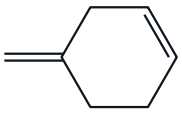


✓

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*



✓



✓

[3 marks]

17(c)(ii)

NaI / KI **AND** H_2SO_4 ✓

[1 mark]

ALLOW *HI*

ALLOW *NaI / KI* ***AND*** *H_3PO_4 OR HNO_3*

IGNORE *Conc or dilute*

17(d)

Structures 1 mark

$CH_3CH_2CH_2CH_2OH$

AND $CH_3CH_2CHOHCH_3$

AND $(CH_3)_2CHCH_2OH$

AND $(CH_3)_3COH$ ✓

Number of peaks 3 marks

$CH_3CH_2CH_2CH_2OH$/ butan-1-ol OR $CH_3CH_2CHOHCH_3$ / Butan-2-ol have 4 peaks/environments/types of carbon ✓

$(CH_3)_2CHCH_2OH$/ (2-)methylpropan-1-ol has 3 peaks/environments/types of carbon ✓

$(CH_3)_3COH$/(2-)methylpropan-2-ol has 2 peaks/environments/types of carbon ✓

Statement 1 mark

$(CH_3)_2CHCH_2OH$/(2-)methylpropan-1-ol can be distinguished (from any other isomer)

OR

$(CH_3)_3COH$/(2-)methylpropan-2-ol can be distinguished (from any other isomer)

OR

$CH_3CH_2CH_2CH_2OH$/ butan-1-ol **AND** $CH_3CH_2CHOHCH_3$/ butan-2-ol cannot be distinguished ✓

[5 marks]

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

Note: all 4 structures are needed for the mark. Additional incorrect structures prevent this mark being awarded.

IGNORE *chemical shifts*

IGNORE *incorrect name if structure given*

ALLOW *correct number of peaks linked to an incomplete structure e.g. C-C-C-C-OH has 4 peaks (no hydrogens shown)*

Statement mark can only be awarded if candidate compares at least two isomers and determines correct number of peaks for the isomers referred to.

DO NOT ALLOW *ECF from an incorrect number of peaks/environments/types of carbon*

Q25 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

IR causes CFC molecules to produce chlorine radicals that initiate ozone breakdown in the upper atmosphere.

Q26 · Alcohols and haloalkanes · [11 marks]

OCR MARK SCHEME

25(a)

$C_5H_{12}O + 7½\ O_2 \rightarrow 5CO_2 + 6H_2O$

EXAMINER GUIDANCE

ALLOW *multiples*

e.g. $2C_5H_{12}O + 15O_2 \rightarrow 10CO_2 + 12H_2O$

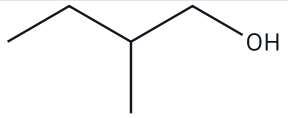
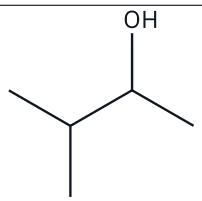
CO_2 AND H_2O products ✓

Complete equation balanced ✓

[2 marks]

Watch for 15/2 **OR** 7.5 for 7½

25(b)

Alcohol	Structure
A	
B	
C	

✓✓✓

[3 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

DO NOT ALLOW *structure if H(s) are missing from ONE structural formula*

..... BUT **ALLOW** any further omissions as ECF

Take care with numbers of carbons, the branches and the position of branching .... especially for C

IGNORE *connectivity,*

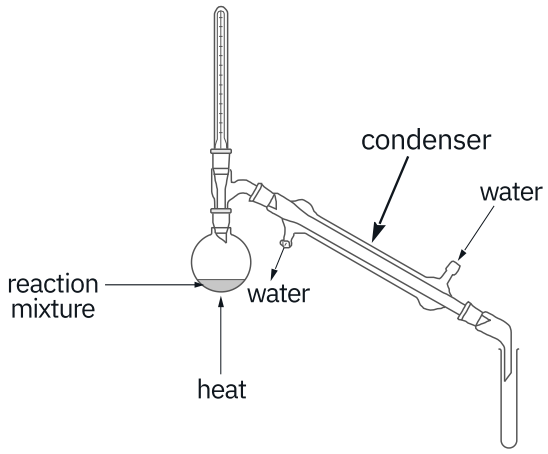
e.g.

ALLOW



BUT **DO NOT ALLOW** –HO

25(c)



Workable set up

- Flask with 'horizontal' **OR** 'angled down' condenser ✓
- **NOT** a sealed system for collection vessel
- **NOT** open at the top above flask

Key labels for distillation set up

- Water in at bottom and out at top
- AND condenser label ✓

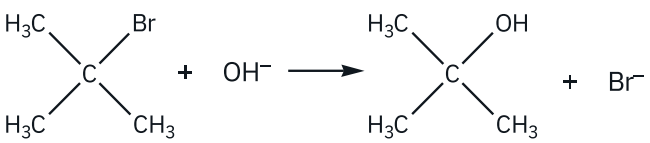
[2 marks]

DO NOT ALLOW *ANY MARKS FOR A REFLUX SET UP*

IGNORE

- no heat *question about apparatus*
- no thermometer *stopper is fine*

25(d)(i)



ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

IGNORE *state symbols*

ALLOW *OH^- AND Br^- in a balanced mechanism*

Structure of BOTH organic compounds ✓

DO NOT ALLOW *if H(s) are missing*

OH^- on left AND Br^- on right ✓

ALLOW *NaOH/KOH with NaBr/KBr*

[2 marks]

ALLOW *OH^- over the arrow for LHS of equation*

DO NOT ALLOW *unbalanced charges,*

e.g. OH^- with Br

DO NOT ALLOW *H_2O AND HBr*

question specifies aqueous alkali.

DO NOT ALLOW *2nd mark if a CON reagent is present,*

e.g. an acid

25(d)(ii)

Rates of hydrolysis of all 3 haloalkanes

Fastest RI > RBr > RCl slowest ✓

Bond enthalpies/strength of bonds for any one RX

Strongest: C–Cl > C–Br > C–I weakest ✓

MUST refer to C–X bond in some way

[2 marks]

IGNORE *reactivity of halogens*

ALLOW *unambiguous comparison of two haloalkanes*

e.g. RI is fastest AND RCl is slowest

ALLOW *C–Cl is strongest bond*

ALLOW *R–Cl, etc BUT **NOT** RCl > RBr > RI no bonds*

DO NOT ALLOW *just 'strongest bond enthalpy*

iodine has weakest bond

Q27 · Alcohols and haloalkanes · [1 mark]

Answer: **D**

Yellow

Q28 · Alcohols and haloalkanes · [1 mark]

Answer: **C**

Bromine water and acidified dichromate(VI).

Q29 · Alcohols and haloalkanes · [1 mark]

Answer: **D**

8.4

Q30 · Alcohols and haloalkanes · [1 mark]

Answer: **C**

OCR MARK SCHEME

3

EXAMINER GUIDANCE

ALLOW 3

Q31 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

The C–I bond enthalpy is less than the C–Br bond enthalpy.

Q32 · Alcohols and haloalkanes · [9 marks]

OCR MARK SCHEME

19(a)(i)

Curly arrow from CN^- to $C^{(\delta+)}$ of C–Br bond ✓

Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$

AND

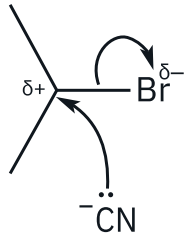
curly arrow from C–Br bond to Br atom ✓

EXAMINER GUIDANCE

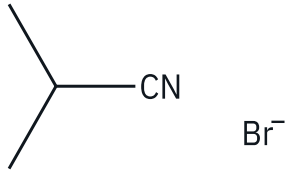
ALLOW *any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

***NOTE**: curly arrows can be straight, snake-like etc., but **NOT** double headed or half headed arrows*

1st curly arrow must:



Correct organic product **AND** Br^- ✓

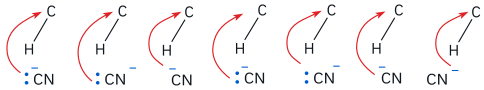


[3 marks]

- go to C of C–Br

AND

- start from, **OR** be traced back to any point across width of the lone pair on C of CN^-
- **OR** start from – charge on C of ^-CN



✓ ✓ ✓ ✓ ✗ ✗ ✗

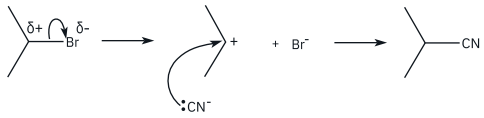
2nd curly arrow must start from, **OR** be traced back to, any part of C–Br bond and go to Br

IGNORE *presence of* K^+

BUT KBr does **NOT** show Br^-

ALLOW *S_N1 mechanism:*

- Dipole on C–Br bond **AND** curly arrow from the C–Br bond to Br ✓
- Correct carbocation **AND** Curly arrow from CN^- to C^+ on carbocation ✓
- Correct organic product **AND** Br^- ✓



19(a)(ii)

Nucleophilic substitution ✓

[1 mark]

19(b)(i)

NaBr **AND** H_2SO_4 ✓

[1 mark]

ALLOW *HBr (**IGNORE** additional acid if given e.g HBr and H_2SO_4)*

ALLOW *KBr instead of NaBr*

ALLOW *H_3PO_4 **OR** HNO_3 in place of H_2SO_4 **BUT NOT** HCl*

ALLOW *PBr_3*

ALLOW *names if no formulae given*

IGNORE *conc **OR** dilute **OR** (aq)*

IGNORE *H^+/Acid (must be clear which acid should be used)*

19(b)(ii)

Step 1

(Add to) separating funnel ✓

(Use of) bottom layer (containing 1-bromopropane / organic) ✓

Step 2

Dry with (one of the following)

- an anhydrous salt
- $MgSO_4$ /magnesium sulfate
- $CaCl_2$ /calcium chloride ✓

Mark each step in order but then don't mark any further if response refers to purification of a solid

e.g. dissolve in minimum amount of hot solvent, evaporate off water to allow solid to crystalise

IGNORE *use of base/carbonate (to remove excess acid) **OR** (saturated) NaCl*

ALLOW *(remove) aqueous layer on the top*

ALLOW *description that aqueous layer can be determined by adding water and seeing which layer increases in size*

Step 3

(Re)Distil (and collect the fraction) at 71°C ✓

[4 marks]

IGNORE *distillation* ***OR*** *filtration prior to* ***step 1 OR step 2***

ALLOW *'to remove water' instead of 'dry'*

IGNORE *any other salt*

IGNORE *filtration to remove anhydrous salt after step 2*

ALLOW *temperature range of 70 – 72°C for distillation*

DO NOT ALLOW *if forms a solid product*

Q33 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

Q34 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

$CH_3CH_2COOH + CH_3NH_3^+$

Q35 · Alcohols and haloalkanes · [1 mark]

Answer: **C**

NaBr and H_2SO_4

Q36 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

Q37 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

electron pair donor · attracted to low electron density

Q38 · Alcohols and haloalkanes · [18 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

5(a)

C, E AND F ✓✓

Three correct alcohols → 2 marks

Two correct alcohols → 1 mark

[2 marks]

If >2 alcohols are shown lose 1 mark for each incorrect response

5(b)

$(CH_3CH_2CHOHCH_3 +) \ 6O_2 \rightarrow 4CO_2 + 5H_2O$ ✓

[1 mark]

DO NOT ALLOW *[O]*

5(c)

2-methylbutan-2-ol ✓

[1 mark]

5(d)(i)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF atom economy = 46.1(%) award 2 marks

Atom economy

$$= \frac{M_r \text{ of } (CH_3)_2CHCH_2CH_2OH}{M_r \ (CH_3)_2CHCH_2CH_2OH + M_r \text{ NaBr}} \times 100$$

ALLOW

$$\frac{M_r \ (CH_3)_2CHCH_2CH_2OH}{M_r \ (CH_3)_2CHCH_2CH_2Br + M_r \ NaOH} \times 100$$

ALLOW *46% up to calculator value (46.09743321)*

ALLOW ECF *from incorrect M_r values*

OR = $\frac{88}{190.9} \times 100$ ✓

= 46.1(%) ✓

[2 marks]

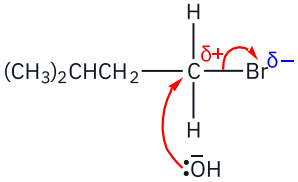
5(d)(ii)

Curly arrows 2 marks

curly arrow from OH^- to C atom of C–Br bond ✓

dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

AND curly arrow from C–Br bond to Br atom ✓



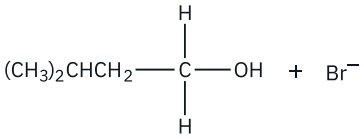
IGNORE *incorrect R groups for curly arrow marks*

IGNORE *presence of* Na^+ *but* OH^- *needed*

i.e. Na^+OH^- can be allowed if criteria met

Products 1 mark

correct organic product **AND** Br^- ✓



IGNORE *presence of* Na^+ *but* Br^- *needed*

i.e. Na^+Br^- can be allowed

BUT NaBr does **NOT** show Br^-

NOTE*: curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

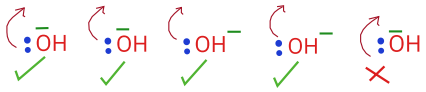
[3 marks]

1st curly arrow must

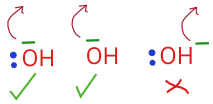
- go to the C of C–Br

AND

- start from, **OR** be traced back to any point across width of lone pair on O of OH^-



- **OR** start from – charge on O of ^-OH ion



(Lone pair **NOT** needed if curly arrow shown from O^-)

2nd curly arrow must start from, **OR** be traced back to, any part of C–Br bond and go to Br

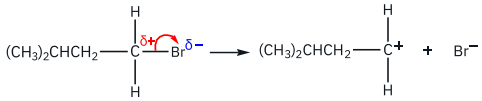


ALLOW *S_N1 mechanism for 2 curly arrow marks*

First mark

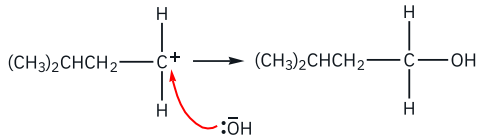
Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,

AND curly arrow from C–Br bond to Br atom ✓



Second mark

Curly arrow from OH^- **AND** to correct carbocation



Use curly arrow criteria in guidance above

5(d)(iii)

Nucleophilic substitution ✓

[1 mark]

5(e)

Rate slower with chloroalkane **ORA** ✓

C–Cl bond is stronger than C–Br bond

IGNORE *reference to bond polarity*

OR C–Cl bond has greater bond enthalpy

OR more energy needed to break C–Cl bond ✓

[2 marks]

5(f)

Level 3 (5–6 marks)

The candidate gives thorough explanations of both spectra, and correctly identifies X and Y with a correct equation.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

The candidate attempts all three scientific points but explanations are incomplete.

OR

Explains two scientific points thoroughly with few omissions.

AND

Attempts a feasible structure based on deduction from correct M_r.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence

Level 1 (1–2 marks)

The candidate gives a simple description based on at least two of the main scientific points.

OR

Gives a thorough description and explanation of one of the scientific points.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

Indicative scientific points

LOOK AT THE SPECTRA for labelled peaks

Mass Spectrum

- M^+ or molecular ion of 86
- $m/z = 43$ shows CH_3CO^+ **OR** $C_3H_7^+$

IR Spectrum

- IR shows no broad absorption at 2500–3300 cm^{-1} so no O–H bond **AND** not a carboxylic acid
- IR shows absorption at 1700 cm^{-1} for C=O bond

OR indicates a ketone/aldehyde present

Identification and Equation

- X must be a secondary alcohol, since refluxing a secondary alcohol with acidified potassium dichromate (VI) forms a ketone

OR primary alcohol → carboxylic acid **AND** tertiary alcohol would not be oxidised.

- X is $(CH_3)_2CHCHOHCH_3$ **OR** compound E

OR 3-methylbutan-2-ol

- Y is $(CH_3)_2CHCOCH_3$ **OR** 3-methylbutan-2-one

Equation

$(CH_3)_2CHCHOHCH_3 + [O] \rightarrow (CH_3)_2CHCOCH_3 + H_2O$

Q39 · Alcohols and haloalkanes · [1 mark]

Answer: **B**

Only 1 and 2

Q40 · Alcohols and haloalkanes · [1 mark]

Answer: **C**

Q41 · Alcohols and haloalkanes · [1 mark]

Answer: **D**

heptan-4-ol

Q42 · Alcohols and haloalkanes · [12 marks]

OCR MARK SCHEME EXAMINER GUIDANCE

7(a)



Correct skeletal formulae for organic compounds ✓

Complete balanced equation ✓

[2 marks]

Skeletal formulae needed for 1st marking point.

For complete balanced equation,

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous,*

e.g. $(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$

7(b)

Level 3 (5–6 marks)

Explains the purification steps with most fine detail.

AND

Calculates correct mass of 2-chloro-2-methylpropane, $(CH_3)_3CCl$

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Describes some purification steps, with some detail.

AND

Calculates the mass of $(CH_3)_3CCl$ with some errors.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Describes few purification steps.

OR

Attempts to calculate the mass of $(CH_3)_3CCl$ with little progress.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

Indicative scientific points may include:

Main purification stages

- Separating funnel to remove organic layer from aqueous layer
- Anhydrous salt to dry organic layer
- Distillation to purify the product

Fine detail

- Organic layer is the top layer
- Name of a drying agent e.g. anhydrous $MgSO_4$ or $CaCl_2$
- Collect fraction at 50 °C

IGNORE *washing with carbonate/water*

not in spec.

Calculation of mass of $(CH_3)_3CCl$

- $n((CH_3)_3COH) = \frac{7.70}{74.0} = 0.10405$ (mol)
- expected $n((CH_3)_3CCl)$

$= 0.10405 \times \frac{76}{100} = 0.0791$ (mol)

- expected mass = 0.0791 × 92.5 = 7.315 g

ALLOW *7.31–7.32 for small slip/rounding*

Using mass

- Theoretical mass $(CH_3)_3CCl$

$= 7.70 \times \frac{92.5}{74.0} = 9.625$ g

- Mass of $(CH_3)_3CCl$ = 9.625 $\times \frac{76}{100} = 7.315$ g

NOTE*: Incorrect inverse ratio of* $\frac{100}{76}$ *gives:*

- $0.10405 \times \frac{100}{76} = 0.137$ (mol)
- Mass = 92.5 × 0.137 = 12.7 g

7(c)(i)

Butan-2-ol ✓

[1 mark]

7(c)(ii)

$(CH_3)_2CHCH_2OH + 2[O] \rightarrow (CH_3)_2CHCOOH + H_2O$

B as reactant: $(CH_3)_2CHCH_2OH$ ✓

$(CH_3)_2CHCOOH$ as product ✓

Correct equation with 2[O] and H_2O ✓

[3 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

If structure of B is a different primary or secondary alcohol, ***ALLOW ECF*** *for product and equation*

Q43 · Alcohols and haloalkanes · [10 marks]

OCR MARK SCHEME

17(a)

Formation of Cl•

$CClF_3 \rightarrow CF_3 \bullet + Cl \bullet$ ✓

Breakdown of O_3

$Cl \bullet + O_3 \rightarrow \bullet ClO + O_2$ ✓

$\bullet ClO + O \rightarrow Cl \bullet + O_2$ ✓

[3 marks]

EXAMINER GUIDANCE

IGNORE *dots for formation Cl•,*

i.e. **ALLOW** $CClF_3 \rightarrow CF_3 + Cl$

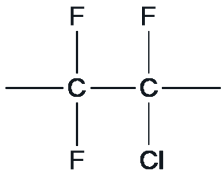
DO NOT ALLOW *ECF*

Dots required in this equation

IGNORE *$O + O_3 \rightarrow 2O_2$*

ALLOW 1 mark *if both equations are correct by atom but dot(s) missing or incorrect*

17(b)(i)



✓

[1 mark]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

'End bonds' MUST be shown

DO NOT ALLOW *more than 1 repeat unit*

IGNORE *brackets*

IGNORE *n*

17(b)(ii)

More points of contact / more surface interaction (between molecules)

AND

Stronger/more dipole(–dipole) interactions ✓

More energy needed to break the intermolecular forces ✓

[2 marks]

Both answers need to be a comparison

IGNORE *surface area*

ALLOW *more electrons*

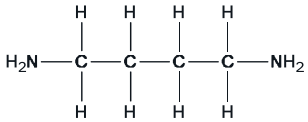
ALLOW *induced/permanent dipole interactions*

ALLOW *London forces*

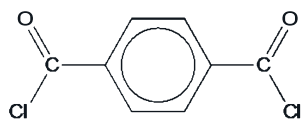
ALLOW *van der Waals' forces (as permanent dipole-dipole and induced dipole-dipole interactions are present within this polymer)*

IGNORE *IDID*

17(c)



✓



✓

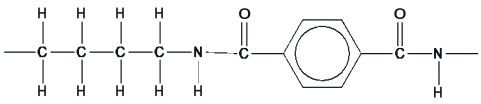
For polymer, DO NOT ALLOW > 1 repeat unit

'End bonds' MUST be shown

(do not have to be dotted)

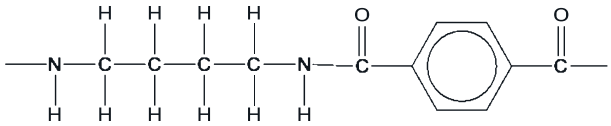
ALLOW *–NH– at either end*

i.e.



IGNORE *brackets*

IGNORE *n*



Amide link: ✓

1 repeat unit of correct polymer: ✓

[4 marks]

Q44 · Alcohols and haloalkanes · [1 mark]

Answer: **A**

Q45 · Alkanes · [1 mark]

Answer: **D**

•Cl + C_3H_7Cl → •C_3H_6Cl + HCl

Q46 · Alkanes · [1 mark]

Answer: **A**

2,3,4-trimethylpentane

Q47 · Alkanes · [1 mark]

Answer: **C**

Only 2 and 3

Q48 · Alkanes · [1 mark]

Answer: **D**

C_5H_{12}

Q49 · Alkanes · [10 marks]

OCR MARK SCHEME

24(a)

Structural isomers: 1 mark

Different structural formulae

AND same molecular formula ✓

Common molecular formula: 1 mark

C_5H_{12} for all 3 hydrocarbons ✓

Boiling point and branching: 1 mark

Boiling point decreases with more branching

OR more methyl/alkyl groups/side chains

OR shorter carbon chain ✓

Branching and London forces: 1 mark

Could be seen anywhere within response

More branching gives less (surface) contact

AND

fewer/weaker London forces ✓

Energy and intermolecular forces: 1 mark

Less energy to break London forces/ intermolecular forces/intermolecular bonds/ ✓

[5 marks]

EXAMINER GUIDANCE

For 'structural':

ALLOW *different structure*

OR different displayed/ skeletal formula

DO NOT ALLOW *any reference to spatial/space/3D*

Same formula is not sufficient (no 'molecular')

Different arrangement of atoms is not sufficient (no 'structure'/'structural')

ALLOW *5 carbons and 12 hydrogens*

ALLOW *for 2 marks:*

Different structural formulae

AND same molecular formula ✓ of C_5H_{12} ✓

Comparisons needed throughout

ORA *throughout*

ALLOW *comparison between any alcohols, e.g.*

A is least branched and has highest b pt

C is most branched and has lowest b pt

ALLOW *induced dipole(–dipole) interactions*

IGNORE *van der Waals'/vdw forces*

ALLOW *SA for surface area*

ALLOW *'harder to overcome intermolecular forces'*

ALLOW *more energy to separate the molecules*

IGNORE *just 'bonds'*

intermolecular/London forces required

24(b)(i)

Radical substitution ✓

ALLOW *Free radical substitution*

[1 mark]

24(b)(ii)

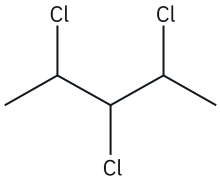
A	B
3 ✓	4 ✓

[2 marks]

24(b)(iii)

Structure of D

Structure of a trichloro isomer of A, e.g.



✓

ALLOW any *trichloro isomer of A*

Equation

$C_5H_{12} + 3Cl_2 \rightarrow C_5H_9Cl_3 + 3HCl$ ✓

Molecular formulae required

NO ECF from incorrect structure of D

ALLOW *correct structural* ***OR*** *displayed*

OR skeletal formula **OR** mixture of the above (as long as unambiguous)

IGNORE *molecular formula*

ALLOW *multiples,*

e.g. $2C_5H_{12} + 6Cl_2 \rightarrow 2C_5H_9Cl_3 + 6HCl$

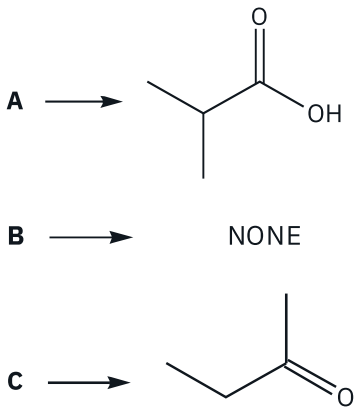
[2 marks]

Q50 · Alkanes · [12 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

25(a)(i)



✓

✓

✓

[3 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

DO NOT ALLOW STICKS IN STRUCTURES

25(a)(ii)

butan-2-ol ✓

[1 mark]

IGNORE *lack of hyphens, or addition of commas*

ALLOW *butane-2-ol*

DO NOT ALLOW *butan-3-ol* ***OR*** *but-2-ol*

25(a)(iii)

$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$ ✓

[1 mark]

25(b)(i)

Initiation

$Cl_2 \rightarrow 2Cl\bullet$ **AND** UV ✓

Propagation

$C_4H_{10} + Cl\bullet \rightarrow C_4H_9\bullet + HCl$ ✓

$C_4H_9\bullet + Cl_2 \rightarrow C_4H_9Cl + Cl\bullet$ ✓

[3 marks]

Dots **NOT** required for initiation

IGNORE *temperature* ***OR*** *pressure*

Dots required in each propagation equation

ALLOW *1 mark for BOTH propagation equations with any dots missing or extra dots*

e.g. $C_4H_{10} + Cl \rightarrow C_4H_9 + HCl$

$C_4H_9\bullet + Cl_2\bullet \rightarrow C_4H_9Cl + Cl$

DO NOT ALLOW *charges*

25(b)(ii)

$C_4H_{10} + 10Cl_2 \rightarrow C_4Cl_{10} + 10HCl$ ✓

[1 mark]

ALLOW *structural formulae, e.g.*

$CH_3CH_2CH_2CH_3 + 10Cl_2 \rightarrow CCl_3CCl_2CCl_2CCl_3 + 10HCl$

25(b)(iii)

$n(E) = \frac{78.0}{32500} = 2.4(0) \times 10^{-3}$ (mol) ✓

$M(E) = \frac{0.636}{2.4(0) \times 10^{-3}}$ **OR** 265 ✓

Molecular formula = $C_4H_4Cl_6$ ✓

[3 marks]

ALLOW ECF *from incorrect n(E)*

ALLOW ECF *from incorrect M(E) from n(E)*

COMMON ERROR

$n(E) = \frac{78.0}{24000} = 3.25 \times 10^{-3}$ (mol) ✗

$M(E) = \frac{0.636}{3.25 \times 10^{-3}} = 195.69$ **OR** 196 ✓

(3SF or more)

Molecular formula = $C_4H_6Cl_4$ ✓

ALLOW ECF *for molecular formula but must be derived from a calculated value for M(E)*

Q51 · Alkanes · [1 mark]

Answer: **A**

$CH_3(CH_2)_5CH_3$

Q52 · Alkanes · [1 mark]

Answer: **D**

$\bullet Cl + C_4H_9Cl \rightarrow \bullet C_4H_8Cl + HCl$

Q53 · Alkanes · [1 mark]

Answer: **D**

OCR MARK SCHEME

9

EXAMINER GUIDANCE

ALLOW *9*

Q54 · Alkanes · [1 mark]

Answer: **D**

propane

Q55 · Alkanes · [13 marks]

OCR MARK SCHEME

5(a)(i)

UV **OR** ultraviolet ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *Sunlight*

IGNORE *Temperature*

5(a)(ii)

$CH_3CH_2CH_2CH_3 + Br\bullet \rightarrow CH_3CH_2C\bullet HCH_3 + HBr$ ✓

$CH_3CH_2C\bullet HCH_3 + Br_2 \rightarrow CH_3CH_2CHBrCH_3 + Br\bullet$ ✓

[2 marks]

ALLOW *Displayed or Skeletal formulae*

ALLOW 1 mark *if BOTH equations are 'correct' using molecular formulae, i.e.*

$CH_3CH_2CH_2CH_3 + Br\bullet \rightarrow C_4H_9\bullet + HBr$

$C_4H_9\bullet + Br_2 \rightarrow C_4H_9Br + Br\bullet$ ✓

IGNORE *position of • within* $CH_3CH_2CHCH_3\bullet$

ALLOW 1 mark *if incorrect structure of intermediate radical is used, e.g.*

$CH_3CH_2CH_2CH_2\bullet$ for $CH_3CH_2CHCH_3\bullet$ ✓

5(a)(iii)

Further substitution

OR

formation of di/ tri / etc. bromobutanes

OR

produces different termination products

OR

more than one termination step ✓

Formation of 1-bromobutane

OR (Br) subsitution in a different position ✓

[2 marks]

ALLOW *multisubstitutation, including examples*

ALLOW *an example of a different termination product*

ALLOW *more than one hydrogen (atom) can be replaced*

ALLOW *radicals react with each other to form other products*

5(b)

% atom economy for butane and bromine (5.1) = $\frac{136.9}{217.8} \times 100 = 62.9\%$ ✓

atom economy for but-2-ene and HBr (5.2) is 100% ✓

Calculator: 62.85583104

ALLOW *calculation for 5.2*

ALLOW *Calculations not expressed as a % i.e. 0.629 and 1.*

[2 marks]

5(c)(i)

FIRST CHECK THE ANSWER ON ANSWER LINE

If answer = 8.07 g award 3 marks

CARE: Intermediate rounding may give 8.06 g which is acceptable for 3 marks

n(2-bromobutane) = $\frac{10.0}{136.9}$ = 0.073(0).... (mol) ✓

$n(CH_3CH_2CHOHCH_3)$ = 0.0730.... × $\frac{100}{67.0}$ = 0.109 (mol) ✓

mass $CH_3CH_2CHOHCH_3$ = 0.109 × 74.0 = 8.07 g ✓

3 SF required

[3 marks]

ALLOW ECF throughout

IGNORE *trailing zeroes in intermediate working, e.g. 0.073 for 0.0730*

ALLOW *3 SF or more, correctly rounded*

Calculator: 0.7304601899

Calculator: 0.1089552239

ALLOW alternative method mass

- Theoretical mass of 2-bromobutane = 100 × $\frac{10.0}{67.0}$ = 14.9..... (g)

Calculator: 14.925373

- Theoretical $n(CH_3CH_2CHBrCH_3)$ = $\frac{14.923373}{136.9}$ = 0.1902 (mol)
- Mass of $CH_3CH_2CHOHCH_3$ = 0.109 × 74.0 = 8.07 g ✓

Common Errors for 2 marks

5.41 g (no % yield)

3.62 g (inverted yield)

5(c)(ii)

Separating funnel (to separate aqueous and organic layers) ✓

Dry organic layer with anhydrous salt ✓

Distil and collect fraction at 91 °C ✓

[3 marks]

ALLOW *Use a drying agent*

ALLOW *appropriate example of an anhydrous salt e.g. $MgSO_4$, $CaCl_2$*

Q56 · Alkanes · [1 mark]

Answer: **D**

Only 1

Q57 · Alkanes · [1 mark]

Answer: **D**

C_5H_{12}

Q58 · Alkanes · [8 marks]

OCR MARK SCHEME

25(a)

Each marking point is independent

Chain length: interaction between molecules

Chain length (in pentane) is longer

AND

more (surface) contact

OR greater surface area/SA ✓

London forces: strength and energy

Stronger / more London forces

OR more energy to break London forces ✓

EXAMINER GUIDANCE

Comparisons needed throughout

ORA *throughout*

Assume the following for longer chain

- larger/bigger molecule
- more C (and H)
- more atoms
- more electrons

BUT 'branching' is a CON

IGNORE *comments about packing*

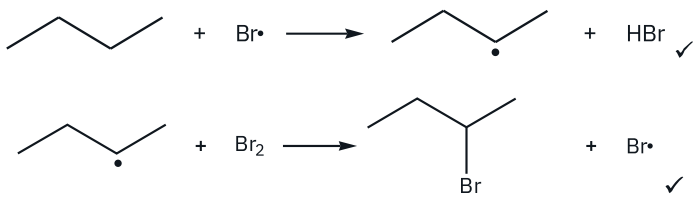
[2 marks]

ALLOW *induced dipole(–dipole) interactions for London forces*

IGNORE *van der Waals'/vdw forces*

25(b)

Skeletal formulae required



[2 marks]

ALLOW *1 mark (**ECF**) for 2 'correct' equations with dot omitted or incorrectly positioned*

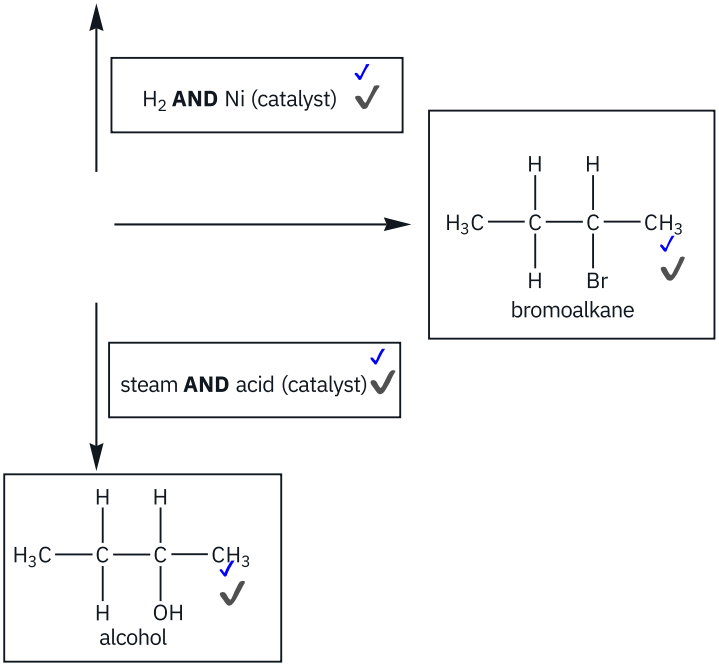
ALLOW *1 mark for forming 1-bromobutane with dots correct for 1-bromobutane*

e.g.



No credit for responses using molecular formulae for organic structures

25(c)



[4 marks]

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

ALLOW *Pt OR Pd for Ni*

ALLOW *$H_2O(g)$ for steam*

(g) OR temperature >100°C required

For acid,

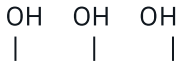
ALLOW *$H^+/H_2SO_4/H_3PO_4$*

ALLOW *small slip in acid formula*

e.g. phosphoric acid as H_2PO_3, etc

ALLOW *vertical bond to any part of OH,*

i.e.



BUT **DO NOT ALLOW** –HO OR OH–

Q59 · Alkanes · [15 marks]

OCR MARK SCHEME

16(a)

Trend for all 3 hydrocarbons (1 mark):

Boiling point increases with less branching

OR less methyl/alkyl groups/side chains ✓

Explanation with comparison (3 marks):

Branching and surface contact

(Less branching gives) more (surface) contact / interaction (between molecules) ✓

Surface contact and London forces

(More surface contact) gives more /stronger induced dipole(–dipole) interactions/ London forces ✓

Energy and intermolecular forces

EXAMINER GUIDANCE

Comparisons needed throughout

ORA *throughout*

Must have link between rank order of branching and boiling point for all 3.

ALLOW *Hexane is least branched/straight chain and has highest bp AND 2,2-dimethylbutane is most branched and has lowest bp.*

IGNORE *Chain length*

Surface area alone is not sufficient, must have idea of contact.

DO NOT ALLOW *arguments comparing different numbers of electrons (as all have the same number).*

More energy to break induced dipole(–dipole) interactions/ London forces/intermolecular forces/intermolecular bonds (with less branching) ✓

[4 marks]

IGNORE *van der Waals'/vdW forces OR IDID OR IDD*

ALLOW *'more energy to break intermolecular forces' if intermolecular forces are not identified or incorrect.*

IGNORE *harder to overcome/break intermolecular forces (no reference to energy)*

IGNORE *just 'bonds'*

intermolecular/London forces required

16(b)(i)

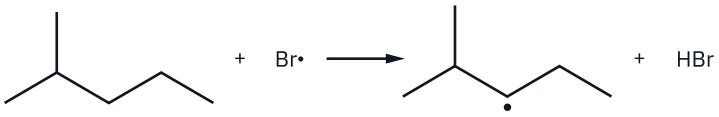
Initiation

$Br_2 \rightarrow 2Br\bullet$

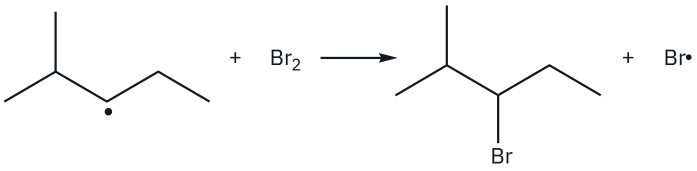
AND

ultraviolet / UV ✓

Propagation



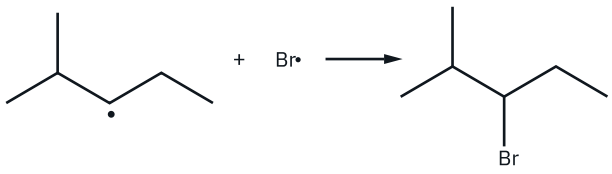
✓



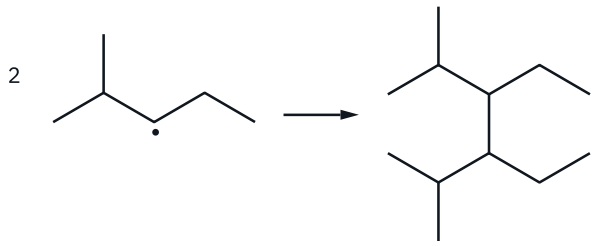
✓

Termination

$2Br\bullet \rightarrow Br_2$ ✓



✓



✓

[6 marks]

DOT REQUIRED throughout

IGNORE *temperature and pressure*

ALLOW ECF for use of Cl• (from Cl_2) in subsequent propagation and termination steps

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

ALLOW *1 mark for propagation for 2 'correct' equations but with dot omitted or in wrong position*

DO NOT ALLOW ECF *from incorrect radical intermediate for termination steps*

16(b)(ii)

C_6Br_{14} ✓

Correct balanced equation

ALLOW *1 mark for correct balanced equation using any combination of skeletal OR structural OR displayed formula*

$C_6H_{14} + 14Br_2 \rightarrow C_6Br_{14} + 14HBr$ ✓

[2 marks]

16(b)(iii)

$n(B) = \frac{72.0}{40000}$ OR $\frac{0.072}{40}$ OR $1.8(0) \times 10^{-3}$ (mol) ✓

$M(B) = \frac{0.8649}{1.8(0) \times 10^{-3}} = 480.5$ ✓

Molecular formula = $C_6H_9Br_5$ ✓

[3 marks]

ALLOW *2SF up to calculator value*

ALLOW ECF from incorrect n(B)

ALLOW ECF from incorrect M(B) from n(B)

COMMON ERROR

$n(B) = \frac{72.0}{24000} = 3 \times 10^{-3}$ (mol) ✗

$M(B) = \frac{0.8649}{3 \times 10^{-3}} = 288.3$ ..... ✓

Molecular formula = $C_6H_{12}Br_2$ OR $C_6H_{11}Br_3$ ✓

ALLOW ECF for viable molecular formula with C_6 but must be derived from a calculated value for M(B)

Q60 · Alkanes · [1 mark]

Answer: **B**

hexane

Q61 · Alkanes · [1 mark]

Answer: **C**

Low polarity of σ-bonds.

Q62 · Alkanes · [14 marks]

OCR MARK SCHEME

24(a)

CHECK FOR RESPONSES ON TABLE

Trend

Boiling point decreases with more branching OR fewer methyl/alkyl groups/side chains ✓

Branching and surface contact

Could be seen anywhere within response

Branching linked to the amount of (surface) contact / interaction/overlap (between molecules) ✓

Type and strength of intermolecular force

Could be seen anywhere within response

Branching/ boiling points/contact linked to strength of London forces OR induced dipole(–dipole) interactions

OR extent of surface contact ✓

Energy and intermolecular forces

Linked to energy seen anywhere

More energy to break intermolecular forces with less branching ✓

IGNORE *just 'bonds'*

intermolecular or type of forces required

[4 marks]

EXAMINER GUIDANCE

Comparisons needed throughout

ORA *throughout*

ALLOW *comparison between 2 alkanes, e.g.*

C has greatest branching AND lowest boiling point

A has no branching AND highest boiling point

IGNORE *Chain length*

Surface area alone is not sufficient

must have idea of contact.

DO NOT ALLOW *responses comparing different numbers of electrons (as all have the same number).*

ALLOW *more branching results in fewer London forces*

ORA

IGNORE *van der Waals'/vdW forces*

OR IDID OR IDD

ALLOW *more energy to break/overcome London forces*

OR induced dipole(–dipole) interactions

OR vdW forces

IGNORE *harder to overcome/break intermolecular forces (no reference to energy)*

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

DO NOT ALLOW *charged formulae*

IGNORE *position of dots within a formula*

DO NOT ALLOW *if reagents also present, e.g..steam*

ALLOW *•CCH_5 for C_2H_5•*

ALLOW $C_2H_5C_2H_5$ for C_4H_{10} ✓

24(b)

CORRECT DOTS REQUIRED FOR ALL MARKS

Initiation

ultraviolet / UV

AND

$Br_2 \rightarrow 2Br\bullet$ OR $Br_2 \rightarrow Br\bullet + Br\bullet$

OR Br–Br → 2Br•, etc ✓

Propagation

1 $C_2H_6 + Br\bullet \rightarrow C_2H_5\bullet + HBr$ ✓

2 $C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$ ✓

Termination

In either order:

$C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ OR $2C_2H_5\bullet \rightarrow C_4H_{10}$ ✓

$C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$ ✓

[5 marks]

ALLOW *109–110 for C1*

ALLOW *118–122 for C2*

ALLOW *planar triangle*

ALLOW *table responses if in wrong columns*

IGNORE *areas of electron density*

For bonded pairs

ALLOW *bp, bonded groups, bonded atoms*

Bonded/bonding essential

For C2, **ALLOW**

- 3 bonded areas/environments
- 3 bonded pairs/groups/atoms
- 2 bonded pairs and 1 double bond
- 2 bonded pairs and 1 bonded region

DO NOT ALLOW *'atoms repel'*

IGNORE

- electrons repel
- bonds repel
- electron region OR electron density
- lone pairs repel more *irrelevant here*
- shapes, even if wrong

24(c)

Carbon atom	Bond angle	Name of shape
1	109.5	tetrahedral
2	120	trigonal planar

2 OR 3 correct ✓

4 correct ✓

Number of electron pairs

In C1/109.5°, 4 bonded pairs/bonding regions/bonds ✓

In C2/120°, 3 bonded regions/bonds ✓

Electron pair repulsion

Electron pairs/bonded pairs repel (as far apart as possible) ✓

Electron pairs/bonded pairs essential

DO NOT ALLOW *'bonded atoms' for this mark*

[5 marks]

Q63 · Alkanes · [1 mark]

Answer: **C**

3.00 dm^3 CO and 2.00 dm^3 O_2

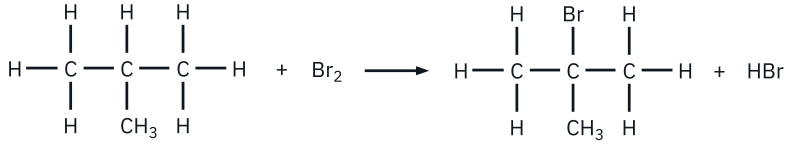
Q64 · Alkanes · [14 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

18(a)(i)

Equation



✓

Name

Radical substitution ✓

Bond fission

homolytic (fission) ✓

[3 marks]

ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

IGNORE *mechanism, need overall equation*

18(a)(ii)

Further substitution/s

OR

Different termination products

OR

More than one termination step

Substitution at different positions along (carbon) chain ✓

[2 marks]

ALLOW dibromo/multibromo compounds formed

OR example of further substitution product e.g $CH_2BrCBr(CH_3)_2$ / $C_4H_8Br_2$ / 1,2-dibromo-2-methylpropane

OR example of different organic termination product e.g.C_8H_{18}

ALLOW more than one H (atom) can be replaced

ALLOW radicals react with each other to form other products

ALLOW a hydrogen (atom) on a different carbon (atom) can be replaced

ALLOW Substitutions can occur at other carbons (along the chain)

ALLOW example of substitution at different position on chain e.g. $CH_2BrCH(CH_3)_2$ / 1-bromo-2-methylpropane

IGNORE *references to separation of products*

IGNORE *references to atom economy or yield*

18(b)

ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

DO NOT ALLOW *structure if H(s) are missing from ONE structural/displayed formula...*

BUT ALLOW any further omissions as **ECF**

ALLOW any vertical bond to the OH OR NH_2



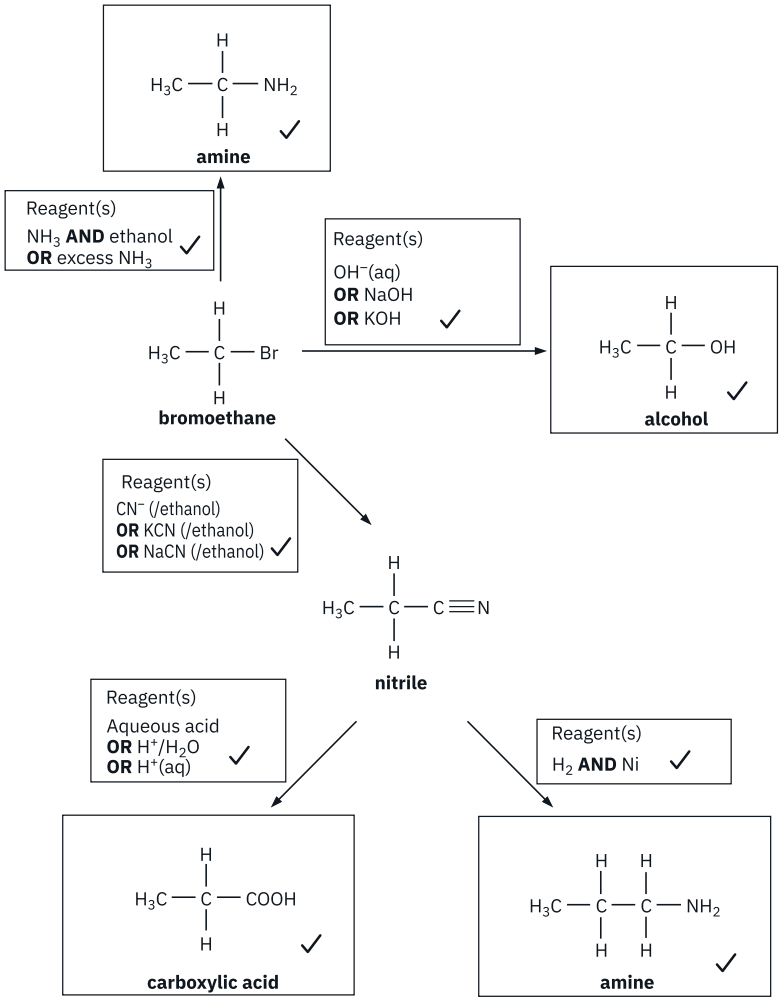
DO NOT ALLOW *OH^-, OR NH_2^- but* ***ALLOW ECF*** *for subsequent use in this part*

ALLOW names of reagents e.g. ethanolic ammonia, if no formulae given

DO NOT ALLOW *other additional reagents*

IGNORE *Conditions*

For bromoethane to amine:



Check has 3C not 2C

[9 marks]

***IF** a secondary / tertiary amine is given ALLOW one mark for a correct structure AND one mark for an appropriate reagent to produce the amine shown.*

For bromoethane to alcohol:

ALLOW H_2O

***IGNORE** ethanol (as a solvent)*

For bromoethane to nitrile:

***DO NOT ALLOW** HCN OR CN^- / H^+*

***DO NOT ALLOW** H_2O / (aq)*

For nitrile to carboxylic acid:

ALLOW any mineral acid

***IGNORE** dilute/concentrated*

For nitrile to amine:

ALLOW suitable non-specification alternative e.g. $LiAlH_4$, H_2 with Pd or Pt

---

Q65 · Alkanes · [1 mark]

Answer: **C**

$CCl_2F_2 \rightarrow \bullet Cl + \bullet CClF_2$

Q66 · Alkanes · [1 mark]

Answer: **D**

$ClO\bullet + O \rightarrow Cl\bullet + O_2$

Q67 · Alkanes · [17 marks]

OCR MARK SCHEME

4(a)

Trend:

Boiling point increases (down the series)

AND

As chain length increases ✓

Explanation:

More (surface) contact / interaction (between molecules) ✓

More /stronger induced dipole(–dipole) interactions/ London (dispersion) forces (between molecules) ✓

EXAMINER GUIDANCE

Comparisons needed throughout

***ORA** throughout*

***IGNORE** references to Enthalpy of Combustion*

***ALLOW** the following for 'chain length increases'*

- Longer molecule/alkane
- Number of carbons increases (question says they are straight chain alkanes)

***DO NOT ALLOW** reference to presence of branching*

More energy to break induced dipole(–dipole) interactions/London forces/intermolecular forces/intermolecular bonds ✓

[4 marks]

Surface area alone is not sufficient, must have idea of contact.

IGNORE *comments about packing*

ALLOW *more electrons (as chain length increases)*

IGNORE *van der Waals'/vdw forces*

DO NOT ALLOW *reference to other intermolecular forces e.g. permanent dipole(-dipole) or hydrogen bonding.*

ALLOW *'more energy to break intermolecular forces' if intermolecular forces are not identified or incorrect.*

IGNORE *harder to overcome/break intermolecular forces (no reference to energy)*

IGNORE *just 'bonds' intermolecular/London forces required*

DO NOT ALLOW *Covalent bonds break*

4(b)(i)

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ ✓

[1 mark]

IGNORE *state symbols*

DO NOT ALLOW *multiples*

4(b)(ii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

If answer = 0.063 ***OR*** *0.0627(g) award 2 marks*

Mass CO_2 produced from one mole C_5H_{12}

= 5 x 44.0 **OR** 220 (g) ✓

Mass of CO_2 produced per 1.00 kJ

$= \frac{220}{3509} = 0.0627$ (g) ✓

[2 marks]

ALLOW ECF *from incorrect mole ratio in equation (b)(i)*

calculator value 0.06269592476

IGNORE *significant figures, marks can be awarded based on correct method e.g.* ***ALLOW*** *0.06 for final answer provided working is shown*

Alternative approaches:

The calculation has 3 steps which can be done in any order:

- X 5
- X 44
- Divide by 3509

Need 2 steps for first mark, and final step scores second mark.

Moles of CO_2 per 1.00 kJ

$= (\frac{1.00}{3509}) \times 5$ **OR** $1.4249... \times 10^{-3}$ ✓

Mass of CO_2 produced per 1.00 kJ

$= 1.4249... \times 10^{-3} \times 44 = 0.0627$ (g) ✓

OR

Mass of CO_2 per mol per 1.00 kJ

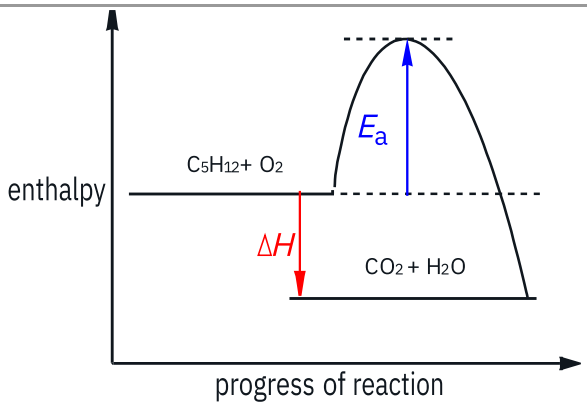
$= \frac{44}{3509}$ **OR** 0.012539... ✓

Mass of CO_2 produced per 1.00 kJ

= 0.012539... x 5 = 0.0627 (g) ✓

4(b)(iii)

IGNORE *state symbols*



Reactants, products and E_a

Reactants on LHS $C_5H_{12} + O_2$

AND

Products on RHS $CO_2 + H_2O$

AND

Activation energy correctly labelled / E_a ✓

ΔH

ΔH labelled with product below reactant

AND

Arrow downwards ✓

[2 marks]

ALLOW *1 mark for a correctly labelled endothermic diagram*

IGNORE *stoichiometry even if incorrect*

ALLOW ECF *from incorrect reactant and products in equation (b)(i)*

For Ea, **ALLOW** AE **OR** A_E

ALLOW *arrowheads at each end of E_a line* ***OR*** *no arrowhead*

BUT **DO NOT ALLOW** arrowhead down

E_a line must reach maximum (or near to maximum) on curve

DO NOT ALLOW *–ΔH*

DO NOT ALLOW *double headed arrow on ΔH*

ALLOW *ΔH arrow even with small gap at the top and bottom, i.e. line does not quite reach reactant or product line.*

ALLOW *–3509 for ΔH*

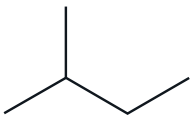
4(b)(iv)

–2900 (kJ mol^{-1}) ✓

[1 mark]

Must be 2 SF with negative sign

4(c)

	
(2-)methylbutane	(2,2-)dimethylpropane

✓✓

[2 marks]

ALL 4 points → 2 marks

2 **OR** 3 points → 1 mark

Structures must be skeletal

Numbers in names are not required but if given must be correct

IGNORE *lack of hyphens, extra hyphens, or addition of commas*

DO NOT ALLOW *the following for methyl: methy, meth, methly*

4(d)(i)

$C_3H_8 + Br_2 \rightarrow C_3H_7Br + HBr$ ✓

[1 mark]

IGNORE *state symbols*

4(d)(ii)

(covalent/Br-Br) bond breaks

AND

each (bonding) atom / Br receives one electron from the bonding / shared pair ✓

[1 mark]

ALLOW *the breaking of (a covalent/Br-Br) bond where each atom keeps one of the bonding electrons*

ALLOW *when a bond breaks one electron from the bond goes to each product / species / radical*

DO NOT ALLOW *'molecule' or 'compound' or 'particle' or 'element' for 'atom'*

IGNORE *homolytic fission equations*

4(d)(iii)

$C_3H_8 + Br\bullet \rightarrow \bullet C_3H_7 + HBr$ ✓

$\bullet C_3H_7 + Br_2 \rightarrow C_3H_7Br + Br\bullet$ ✓

[2 marks]

ALLOW *dot at any position on the radical*

ALLOW *1 mark if both equations correct but any dots omitted from radicals*

4(d)(iv)

Br can substitute at different positions along (carbon) chain

OR

two different radicals form $CH_3CH_2CH_2$ AND CH_3CHCH_3 ✓

[1 mark]

ALLOW *AW*

e.g

ALLOW *Br can replace an end H or a middle H*

ALLOW *Br can substitute at any C*

IGNORE *position of radical dot on radical structures*

IGNORE *references to minor/major product*

DO NOT ALLOW *stability of carbocations/haloalkanes*

Q68 · Alkanes · [12 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

16(a)

2-methylpent-2-ene ✓

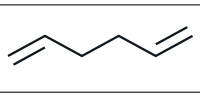
[1 mark]

IGNORE *lack of hyphens, or addition of commas*

DO NOT ALLOW *the following for methyl: methy, meth, methly, methyle, methanyl*

DO NOT ALLOW *2-methylpentan-2-ene*

16(b)

		
Molecular formula	C_6H_{10}	C_6H_{10}
Number of σ bonds	15	16
Number of π bonds	2	1

One row correct ✓

Two rows correct ✓✓

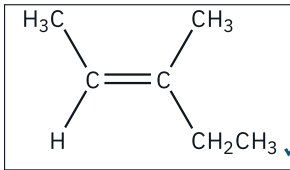
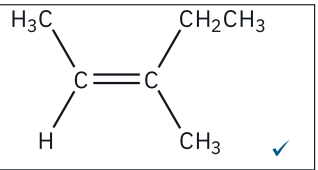
Three rows correct ✓✓✓

[3 marks]

One mark per row

If no other marks awarded, ***ALLOW*** *1 mark for a correct column*

16(c)(i)

	
E	***Z***

[2 marks]

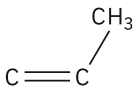
ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *one mark if both stereoisomers of compound A are shown but in the incorrect columns*

ALLOW *$-C_2H_5$ for ethyl group*

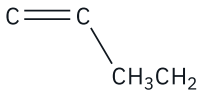
ALLOW *connectivity to any part of methyl or CH_2 in ethyl*

e.g.



BUT DO NOT ALLOW ethyl group bonded via CH_3

e.g. $-CH_3CH_2$



16(c)(ii)

C=C / double bond does not rotate

OR restricted rotation of the C=C/double bond ✓

Each carbon atom in C=C/double bond has (two) different groups/atoms (bonded) ✓

[2 marks]

ALLOW *π/pi bond does not rotate*

ALLOW *C=C / double bond does not twist*

IGNORE *groups are fixed in position*

IGNORE *'bond does not move'* ***OR*** *'bond has restricted movement'*

ALLOW *each end of the π/pi -bond is bonded to different groups/atoms*

DO NOT ALLOW *'functional groups'* ***OR*** *'molecules'* ***OR*** *'compounds'* ***OR*** *'species' for 'groups'*

IGNORE *C=C bond has two different groups*

IGNORE *two different groups either side of the double bond (could be above or below must be clear it is on each C)*

IGNORE *references to 'priority' (even if incorrect)*

IGNORE *attempts to give definition of stereoisomerism e.g. same structural formula but different arrangement of atoms in space*

16(d)

$C_6H_{14} + 6O_2 \rightarrow 5CO + C + 7H_2O$ ✓

[1 mark]

DO NOT ALLOW *any equations which show H_2 as a product*

ALLOW *$C_6H_{14} + 6O_2 \rightarrow 2CO_2 + CO + 3C + 7H_2O$*

ALLOW *$C_6H_{14} + 6O_2 \rightarrow CO_2 + 3CO + 2C + 7H_2O$*

ALLOW *multiples that show a 1:6 ratio*

e.g. $2C_6H_{14} + 12O_2 \rightarrow 10CO + 2C + 14H_2O$

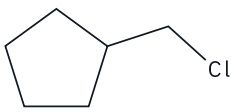
OR $2C_6H_{14} + 12O_2 \rightarrow 5CO_2 + 7C + 14H_2O$

16(e)

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *names for reagents e.g. hydrogen, if no formulae given*

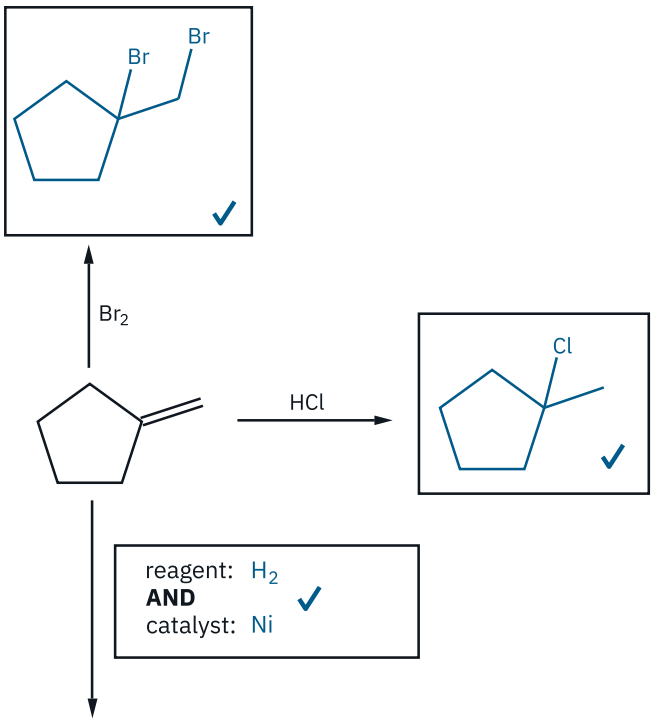
DO NOT ALLOW *minor product, i.e.*



ALLOW *reagent and catalyst on either answer line*

For catalyst **ALLOW** Pt / Pd or any suitable non-specification alternative

IGNORE *state symbols*



IGNORE *conditions i.e. temp and pressure*

[3 marks]

Q69 · Alkanes · [1 mark]

Answer: **C**

High C–C bond enthalpy

Q70 · Alkanes · [9 marks]

OCR MARK SCHEME

16(a)

2-bromo-3,3-dimethylbutane ✓

[1 mark]

EXAMINER GUIDANCE

IGNORE *lack of hyphens or addition of commas*

ALLOW *3,3-dimethyl-2-bromobutane*

DO NOT ALLOW

2-bromo-3-dimethylbutane

methy for methyl

methly for methyl

brom for bromo

16(b)(i)

Stereoisomers

Same structural formula

AND

Different arrangement (of atoms) in space

OR different spatial arrangement (of atoms)

AND

Type: Optical ✓

[1 mark]

ALLOW *structure/displayed/skeletal formula*

DO NOT ALLOW *same empirical formula*

OR same general formula

IGNORE *same molecular formula*

IGNORE *references to chiral molecules/compounds*

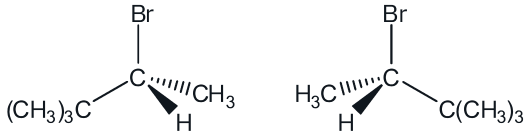
16(b)(ii)

One 3D structure with correct groups attached to the chiral C ✓

Two 3D structures of $(CH_3)_3CCHBrCH_3$ that are mirror images **AND** correct connectivity in both ✓

ALLOW *small slip in one of the groups OR use of* C_4H_9

3D structures must have four central bonds with at least two wedges.

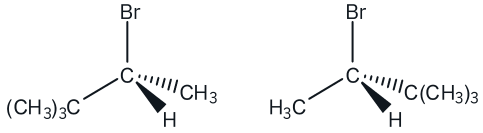


[2 marks]

For bond into paper accept:



ALLOW *two 3D structures with 2 groups swapped e.g.*

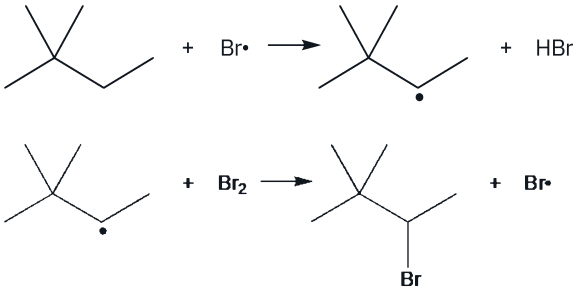


16(c)

Initiation

$Br_2 \rightarrow 2Br\bullet$ ✓

Propagation



✓✓

ALLOW $Br_2 \rightarrow Br\bullet + Br\bullet$

IGNORE *dots for initiation step, i.e.* ***ALLOW*** $Br_2 \rightarrow Br + Br$ ***OR*** $Br_2 \rightarrow 2Br$

DOT REQUIRED at correct position on chain.

ALLOW 1 mark *if both propagation equations are correct by atom but dot(s) missing or on incorrect C in chain*

ALLOW 1 mark *if both propagation equations are correct including position of dot(s) but structures are not shown using skeletal formula*

ALLOW *ECF from incorrect intermediate*

[3 marks]

16(d)

further substitution/s

OR

produces different termination products

OR

More than one termination step

OR

Mixture of products are formed ✓

substitution at different positions along chain ✓

ALLOW *dibromo/multibromo compounds formed*

OR an example of a further substitution product

OR an example of a different termination product

ALLOW *more than one hydrogen (atom) can be replaced*

ALLOW *radicals react with each other to form other products*

IGNORE *references to separation of products*

IGNORE *references to atom economy or yield*

ALLOW *a hydrogen (atom) on a different carbon (atom) can be replaced*

[2 marks]

Q71 · Alkanes · [1 mark]

Answer: **D**

2,2,3-trimethylbutane

Q72 · Alkanes · [6 marks]

OCR MARK SCHEME

2(a)

A species with an unpaired electron ✓

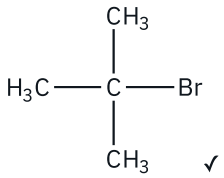
[1 mark]

2(b)

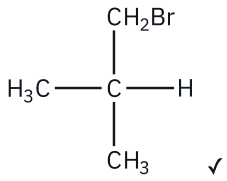
Homolytic (fission) ✓

[1 mark]

2(c)



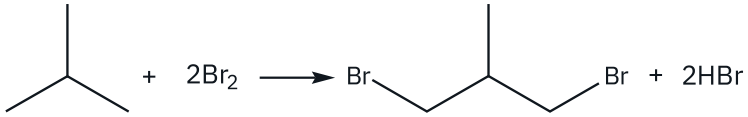
✓



✓

[2 marks]

2(d)



Structure of organic product ✓

Complete balanced equation ✓

[2 marks]

EXAMINER GUIDANCE

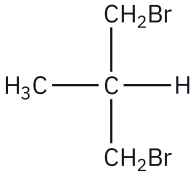
***DO NOT ALLOW**:*

species with one electron

***ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

***ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous,*

e.g.



Q73 · Alkanes · [1 mark]

Answer: **C**

$CH_3CH_2CH_2CH_2OH + 4O_2 \rightarrow 4CO + 5H_2O$

Q74 · Alkenes and addition polymers · [1 mark]

Answer: **D**

σ bonds: 12 · π bonds: 2

Q75 · Alkenes and addition polymers · [8 marks]

OCR MARK SCHEME

26(a)(i)

Alkene **AND** C_nH_{2n} ✓

[1 mark]

26(a)(ii)

Hydrogen/H_2 **AND** Ni (catalyst) ✓

EXAMINER GUIDANCE

***IGNORE** branched before alkene*

***ALLOW** Pt **OR** Pd **OR** Rh*

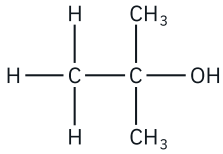
***ALLOW** hydrogenation for hydrogen*

[1 mark]

IGNORE *any temperature and pressure stated*

26(b)

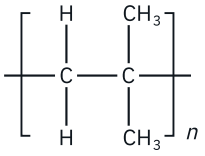
Compound C:



✓

CARE: Tertiary alcohol

Compound D: (repeat unit)



✓

[2 marks]

For structures:

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above*

Connectivity

IGNORE *connectivity of bonds to* CH_3

e.g. **ALLOW** CH_3–

ALLOW any *vertical bond to OH,*

e.g. **ALLOW**

OH **OR** OH

DO NOT ALLOW *OH–*

DO NOT ALLOW *more than one repeat unit*

REQUIRED: Side links (dotted lines fine)

NOT REQUIRED*: Brackets and 'n'*

26(c)(i)

C_2H_5O ✓

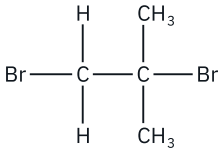
[1 mark]

ALLOW *elements in any order*

DO NOT ALLOW *any other answer*

26(c)(ii)

Compound E:



✓

Stage 1: Compound E: Bromine/Br_2 ✓

Stage 2: NaOH/KOH **OR** OH^- ✓

Only award if intermediate contains at least one halogen atom

[3 marks]

For structures:

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above*

ALLOW *dichloro/diiodo compound*

IGNORE *connectivity of bonds to* CH_3

ALLOW *chlorine/*Cl_2 ***OR*** *iodine/*I_2

IGNORE *conditions, e.g. u.v.*

DO NOT ALLOW H_2O

IGNORE *conditions*

NOTE*: Max of 2 marks available for monobrominated intermediate*

1 mark

Reagent: HBr **AND**

Intermediate: $CH_3C(CH_3)_2Br$ **OR**

$BrCH_2CH(CH_3)_2$

1 mark

Intermediate: $CH_3C(CH_3)_2Br$ **OR**

$BrCH_2CH(CH_3)_2$

AND Reagent: NaOH

Q76 · Alkenes and addition polymers · [12 marks]

OCR MARK SCHEME

3(a)(i)

Any one from:

EXAMINER GUIDANCE

IGNORE *the length of the σ bond and π bond*

IGNORE *the type of orbital for σ bond*

- σ bond is between bonding atoms/nuclei **AND** π bond is above and below the bonding atoms/nuclei
- σ bond has direct/head-on overlap of orbitals **AND** π bond has sideways overlap
- π bond has a lower bond enthalpy / is weaker than a σ bond
- σ bond has electron density between bonding atoms **AND** π bond has electron density above and below bonding atoms ✓

[1 mark]

3(a)(ii)

One carbon atom (in double bond) is attached to two groups which are identical/the same ✓

[1 mark]

ALLOW

- One carbon atom in (double bond) is not attached to (two) different groups / groups of atoms
- Right-hand carbon is attached to two groups that are the same/two methyl groups.
- Two groups are the same on right-hand side
- Three groups are the same (on the double bond)

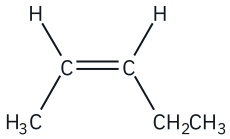
DO NOT ALLOW

- Two groups on the same side of the double bond

Must be right-hand side; Same side could be top or bottom)

- Functional groups **OR** molecules for groups

3(a)(iii)



✓

(Z-)pent-2-ene ✓

[2 marks]

Mark Independently

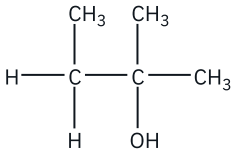
*ALLOW correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous*

ALLOW C_2H_5 for CH_2CH_3

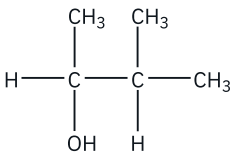
***IGNORE** connectivity of alkyl groups BUT .....**DO NOT ALLOW** $-CH_3CH_2$*

***DO NOT ALLOW** trans-pent-2-ene*

3(b)



✓

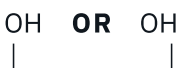


✓

*ALLOW correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous*

ALLOW any vertical bond to OH,

e.g. ALLOW



***DO NOT ALLOW** OH–*

[2 marks]

3(c)

Level 3 (5–6 marks)

A comprehensive description with all three scientific points explained thoroughly.

There is a well-developed and detailed description of the mechanism, including correct structures, accurately drawn curly arrows and using charges and dipoles consistently. Candidates compare tertiary and secondary carbocation stability to justify major product.

Level 2 (3–4 marks)

Attempts to describe all three scientific points but explanations may be incomplete.

OR Explains two scientific points thoroughly with no omissions.

The description has some structures with reasonably accurate curly arrows and some charges and dipoles identified.

Level 1 (1–2 marks)

A simple description based on at least two of the main scientific points

OR Explains one scientific point thoroughly with few omissions.

The description is communicated in an unstructured way, including some use of curly arrows, charges or dipoles.

0 marks

No response worthy of credit.

[6 marks]

Throughout: ALLOW correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above if unambiguous

Indicative scientific points

1. Two possible products of reaction

$CH_3C(CH_3)BrCH_2CH_3$

$CH_3CHBrCH(CH_3)CH_3$

IGNORE *names where correct structures are present*

2. Mechanism for formation of either product.

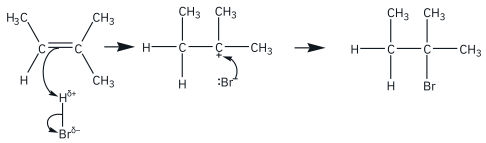
Curly arrow from C=C to attack the H atom of the HBr

Correct dipole on H–Br

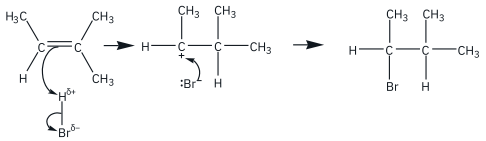
Curly arrow from H–Br bond to Br

Carbocation with full positive charge on carbon atom

Curly arrow from negative charge on Br^- or lone pair on Br^- to carbon atom with positive charge

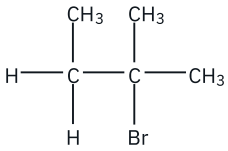


OR



3. Major organic product

Major product: 2-bromo-2-methylbutane



- Major product is formed from the most stable carbocation intermediate **OR** –Br is attached to carbon atom with the least hydrogens attached **OR** the carbon with the most $–CH_3$ groups attached **OR** the –H is attached to the carbon atom with most hydrogens attached

Q77 · Alkenes and addition polymers · [1 mark]

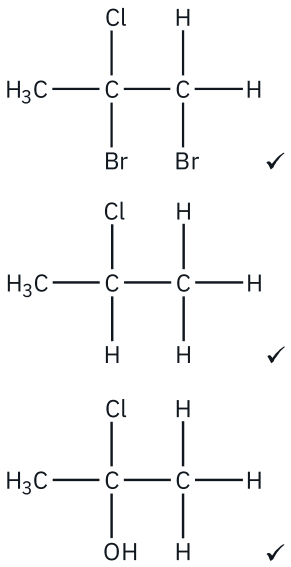
Answer: **A**

E-2-bromobut-2-ene

Q78 · Alkenes and addition polymers · [7 marks]

OCR MARK SCHEME

21(a)(i)



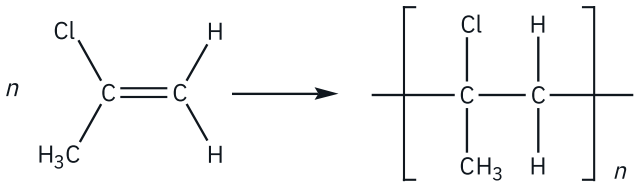
[3 marks]

21(a)(ii)

H^+/acid/H_2SO_4/H_3PO_4 ✓

[1 mark]

21(b)(i)



Correct repeat unit (*n* and brackets not required) ✓

Equation balanced with *n* ✓

TAKE CARE of '*n*' position on both sides of equation.

[2 marks]

21(b)(ii)

Formation of HCl/hydrochloric acid/ **OR** chlorine ✓

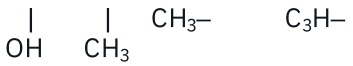
[1 mark]

EXAMINER GUIDANCE

ALLOW *structural* ***OR*** *displayed* ***OR*** *skeletal formula* ***OR*** *mixture of the above (as long as unambiguous)*

For connectivity,

ALLOW



DO NOT ALLOW *OH–*

ALLOW *HCl*

IGNORE *(aq)* ***OR*** *'dilute'* ***OR*** *concentrated*

For monomer,

ALLOW *correct molecular* ***OR*** *structural* ***OR*** *displayed* ***OR*** *skeletal formula* ***OR*** *mixture of the above (as long as unambiguous)*

For repeat unit,

DO NOT ALLOW *molecular formula*

NOTE*: 'side bonds' ARE required on either side of repeat unit from C atoms*

ALLOW *section of polymer containing more than one repeat unit*

NO ECF from incorrect repeat unit

ALLOW *Cl or* Cl_2 *for chlorine*

IGNORE *toxic waste products*

Response must reflect chlorine in some way

Q79 · Alkenes and addition polymers · [20 marks]

OCR MARK SCHEME

16(a)

Compound A (is branched so) has less points of contact / less surface interaction between molecules ✓

Induced dipole–dipole interactions / London (dispersion) forces are weaker.

AND

Require less energy to break (these interactions / forces) ✓

EXAMINER GUIDANCE

Both answers need to be comparisons

ALLOW ORA *throughout*

DO NOT ALLOW *'more contact between atoms'*

IGNORE *van der Waals' forces/VDW for induced dipole–dipole interactions (ambiguous as this term refers to both permanent dipole – dipole and induced dipole–dipole forces)*

[2 marks]

ALLOW *fewer induced dipole-dipole interactions.*

IGNORE *it is easier to break the induced dipole-dipole / London forces. (reference to energy required)*

IGNORE *less energy required to separate molecules*

IGNORE *less energy is needed to break the bonds.*

16(b)(i)

Hex-3-en-1-ol ✓

[1 mark]

ALLOW *Hex-3-ene-1-ol*

ALLOW *1-hydroxyhex-3-ene as this is unambiguous*

Hex-3-enol is not sufficient

IGNORE *lack of hyphens, or addition of commas*

16(b)(ii)

Same structural formula

AND

Different arrangement (of atoms) **in space OR** different spatial arrangement (of atoms) ✓

[1 mark]

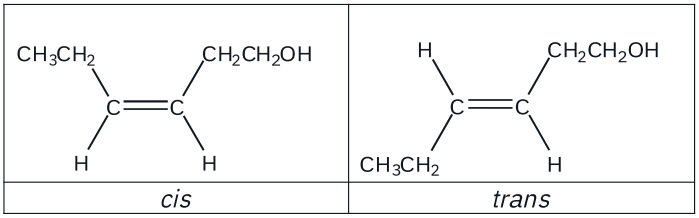
ALLOW *have the same structure/displayed formula/skeletal formula*

DO NOT ALLOW *same empirical formula* ***OR*** *same general formula*

IGNORE *same molecular formula*

Reference to *E*/*Z* isomerism or optical isomerism is not sufficient

16(b)(iii)



✓

✓

[2 marks]

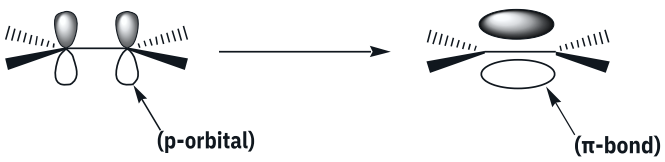
ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *one mark if both stereoisomers of compound C are shown but in the incorrect columns*

ALLOW *one mark for correct stereoisomers of compound C in correct columns where* $-CH_2CH_2OH$ *is represented as* $-C_2H_5O$ *or* $-C_2H_4OH$

DO NOT ALLOW *incorrect connectivity e.g.* $-CH_3CH_2$ *on first occasion but allow* ***ECF*** *in second structure.*

16(c)



Two p-orbitals shown as a “dumb-bell” added to structure on left.

AND

π-bond on structure on right ✓

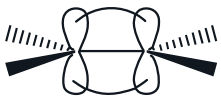
[1 mark]

DO NOT ALLOW *C=C in diagram*

DO NOT ALLOW *overlapping p orbitals on left hand side in the diagram.*

DO NOT ALLOW *a diagram that contains four lobes on the right hand side.*

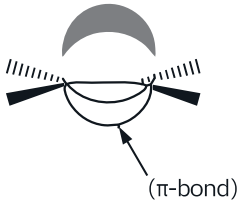
e.g.



IGNORE *any atoms joined to the bonds*

Note: labels are not required

ALLOW *the following diagram to show the π-bond*

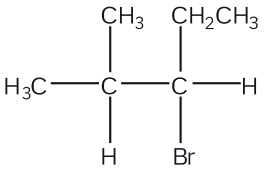


16(d)(i)

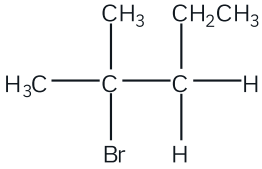
(The H atom of HBr) accepts a pair of electrons ✓

[1 mark]

16(d)(ii)



✓



✓

[2 marks]

ALLOW *correct structural* ***OR*** *displayed* ***OR*** *skeletal formulae* ***OR*** *a combination of above as long as unambiguous*

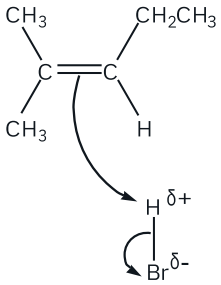
ALLOW *in either order*

16(d)(iii)

Curly arrow from C=C bond to H of H–Br ✓

Correct dipole shown on H–Br

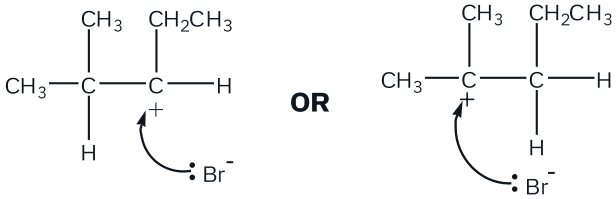
AND curly arrow showing the breaking of H–Br bond ✓



Correct carbocation

AND

curly arrow from Br^- to C^+ of carbocation ✓



[3 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

DO NOT ALLOW *partial charges shown on C=C double bond (the second marking point)*

DO NOT ALLOW *δ+ on C of carbocation*

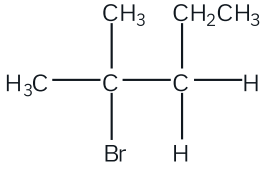
Curly arrow must come from a lone pair on Br^-

OR from the negative sign of Br^- ion

(then lone pair on Br^- ion does not need to be shown)

16(d)(iv)

Note: the correct product and explanation are



2-bromo-2-methylpentane

AND (the) carbocation intermediate (in the formation of 2-bromo-2-methylpentane) is more stable (than the carbocation in the formation of the other product) ✓

[1 mark]

both required for the mark

The major product may be identified by its

- corresponding letter (E or F) from the table in (d)(ii)
- correct structure
- correct name

DO NOT ALLOW *product comes from the more stable secondary or primary carbocation*

IGNORE *explanations based on Markownikoff's rule.*

16(e)(i)

n(myrcene) = $\frac{204 \times 10^{-3}}{136.0}$ = 1.5(0) × 10^{-3} (mol) ✓

Volume of H_2 = 3 × 1.5(0) × 10^{-3} × 24000

= 108 (cm^3) ✓

[2 marks]

Correct working required for the first marking point.

ALLOW ECF *from incorrect moles of myrcene*

i.e. n(myrcene) × 3 × 24000

Common incorrect answers

108000 cm^3 = 1 mark (not converted to g)

12cm^3 = 1 mark (divided by 3)

36 cm^3 = 1 mark (not multiplied by 3)

IGNORE *Calculations based on pV = nRT*

16(e)(ii)

Amount of hydrogen

$n(H_2) = \frac{5.28}{24.0}$ = 0.22(0) (mol) ✓

Number of double bonds

= $\frac{0.220}{0.0200}$ = 11 ✓

Formula of saturated product

$C_{40}H_{78}$ ✓

Equation

$C_{40}H_{56} + 11H_2 \rightarrow C_{40}H_{78}$ ✓

[4 marks]

ALLOW *Evidence of* $n(H_2) = \frac{5.28}{24.0}$ *if 0.22 is not seen*

Evidence for 11 double bonds could come from $11H_2$ in equation

Formula could be shown as the product of an equation

ALLOW ECF *from* $C_{40}H_{82}$ *and* $C_{40}H_{80}$ *only*

i.e. $C_{40}H_{60} + 11H_2 \rightarrow C_{40}H_{82}$

$C_{40}H_{58} + 11H_2 \rightarrow C_{40}H_{80}$

Q80 · Alkenes and addition polymers · [1 mark]

Answer: **B**

Q81 · Alkenes and addition polymers · [1 mark]

Answer: **D**

2,3-dibromopentane

Q82 · Alkenes and addition polymers · [1 mark]

Answer: **C**

Double bond 1: E · Double bond 2: E

Q83 · Alkenes and addition polymers · [9 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

6(a)

steam

AND

Acid/H^+ (catalyst) ✓

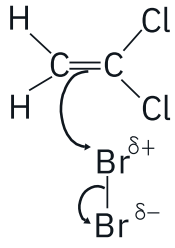
[1 mark]

6(b)(i)

1,2-dibromo-1,1-dichloroethane ✓

[1 mark]

6(b)(ii)



1st curly arrow (from ANY alkene)

Curly arrow from double bond to Br of Br–Br ✓

DO NOT ALLOW *partial charge on C=C*

2nd curly arrow

Correct dipole on Br–Br

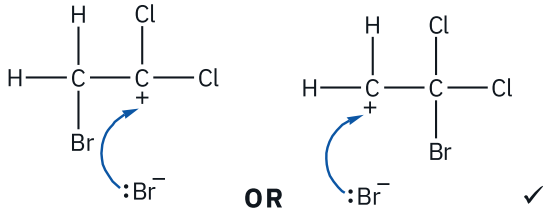
AND curly arrow for breaking of Br–Br bond ✓

3rd curly arrow

Correct carbocation with + charge on C with 3 bonds

AND curly arrow from Br^- to C^+ of carbocation ✓

DO NOT ALLOW *δ+ on C of carbocation*



i.e. ALLOW carbonium + on either C atom

DO NOT ALLOW *half headed or double headed arrows but allow* ***ECF*** *if seen more than once*

[3 marks]

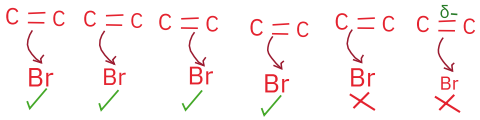
For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples):

1st curly arrow must

- go to a Br atom of Br–Br

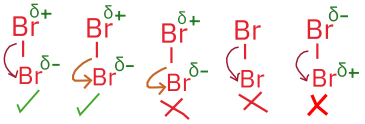
AND

- start from, OR be traced back to any point across width of C=C



2nd curly arrow must

- start from, OR be traced back to, any part of $^{\delta+}Br–Br^{\delta-}$ bond
- AND go to $Br^{\delta-}$

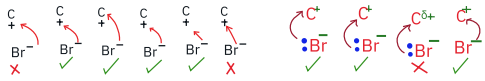


3rd curly arrow must

- go to the C^+ of carbocation

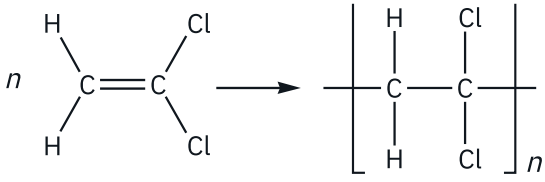
AND

- start from, OR be traced back to any point across width of lone pair on $:Br^-$
- OR start from – charge on Br^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)

6(c)(i)



Correct polymer with side links and brackets ✓

Equation balanced with *n* ✓

TAKE CARE of '*n*' position on both sides of equation.

For repeat unit,

- displayed formula required
- 'side bonds' required on either side of repeat unit from C atoms
- ALLOW section containing more than one repeat unit

DO NOT ALLOW ECF *from incorrect repeat unit*

n on LHS at any height to the left of the formula

[2 marks]

n on RHS must be subscript

6(c)(ii)

Advantage (1 mark)

Energy production / (energy) used to produce electricity ✓

Disadvantage (1 mark)

Formation of HCl/products of combustion cause acid rain

OR

Formation of CO_2/gases that cause global warming / greenhouse gases

OR

Formation of CO ✓

ALLOW reduced use of fossil fuels

ALLOW less landfill / less harm to wildlife

ALLOW chlorine/Cl OR Cl_2

ALLOW toxic/poisonous waste products

[2 marks]

Q84 · Alkenes and addition polymers · [18 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

20(a)

priority groups/atoms are on different/opposite sides ✓

High(est) priority groups are C_6H_5 **AND** CHO

OR

Lowest priority groups are H and CH_3 ✓

***ALLOW** suitable alternatives to 'priority' e.g. groups with highest atomic number or more important groups etc.*

***ALLOW** high priority groups are diagonal(ly across)*

***IGNORE** references to relative mass of groups, A_r, M_r*

***ALLOW** identification by name e.g*

aldehyde for CHO

phenyl/benzene group for C_6H_5

alkyl for CH_3

***ALLOW** response in terms that O has higher priority than H in context of $–CH_3$ and –CHO*

***IF** 'priority' is not mentioned **ALLOW** 1 mark for 'C_6H_5 and CHO are on different sides' **OR** H and CH_3 are on different sides*

[2 marks]

20(b)(i)

Bromine/ Br_2

AND

goes colourless/decolourised ✓

Note: both reagent and observation are required

***ALLOW** bromine water/ Br_2(aq)*

[1 mark]

20(b)(ii)

Tollens' (reagent)

AND

Silver (mirror/precipitate/ppt/solid) ✓

Note: both reagent and observation are required for the mark.

***ALLOW** ammoniacal silver nitrate **OR** Ag^+/NH_3*

***ALLOW** black ppt **OR** grey ppt*

[1 mark]

20(b)(iii)

(Add) 2,4-dinitrophenylhydrazine **AND** orange/yellow/red precipitate ✓

Take melting point (of crystals) ✓

Compare to known values/database ✓

***ALLOW** errors in spelling*

***ALLOW** 2,4(-)DNP **OR** 2,4(-)DNPH*

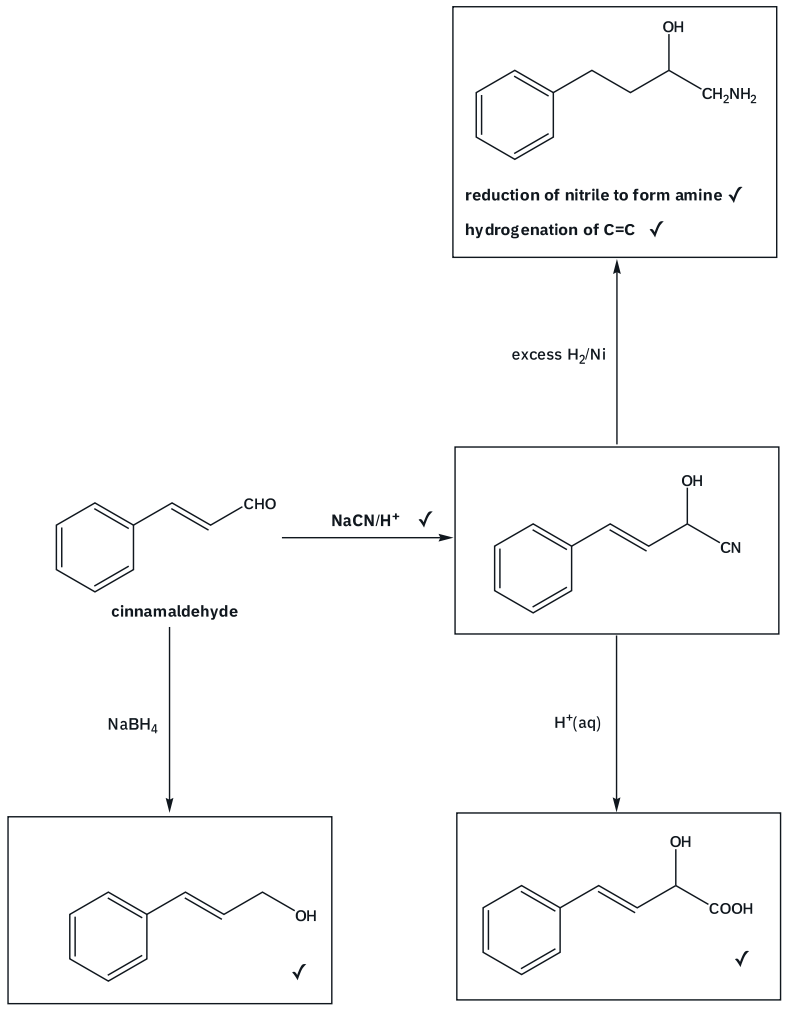
***ALLOW** Brady's reagent or Brady's Test*

***ALLOW** solid **OR** crystals **OR** ppt as alternatives for precipitate*

[3 marks]

20(c)

Marks for each correct structure/reagent shown below



[5 marks]

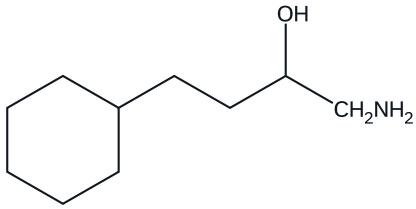
Mark second and third points independently of response for first marking point

DO NOT ALLOW *2nd and 3rd marks for taking and comparing boiling points* ***OR*** *chromatograms*

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

For reaction with excess H_2/Ni **IGNORE** hydrogenation of benzene ring

i.e. the following structure scores two marks



ALLOW *KCN/H+*

ALLOW *HCN*

ALLOW *H_2SO_4 or HNO_3 or HCl for H^+*

20(d)

Level 3 (5–6 marks)

An outline of the mechanism for the formation of either product which is mostly correct.

AND

Major and minor products identified with a correct explanation of which product is most/least likely to be formed.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

An outline of the mechanism for the formation of either product but with a few omissions/errors.

AND

Throughout: **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above if unambiguous

Indicative scientific points:

Mechanism for formation of either product.

- Curly arrow from C=C to attack the I atom of the I-Cl
- Correct dipole on I-Cl
- Curly arrow from I-Cl bond to Cl
- Carbocation with full positive charge on carbon atom
- Curly arrow from negative charge on Cl^- or lone pair on Cl^- to carbon atom with positive charge

Identifies major/minor product correctly **OR** Explanation of which product is most/least likely to be formed.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

A basic outline of the mechanism for the formation of either product is attempted.

OR

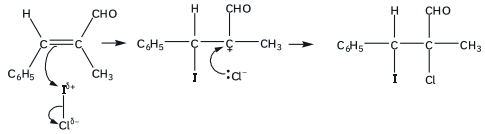
Basic explanation of which of the products is most/least likely to be formed.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

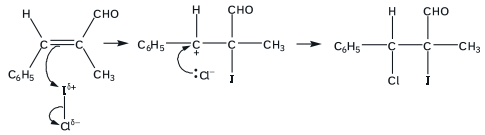
0 marks

No response or no response worthy of credit.

[6 marks]

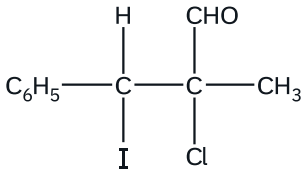


OR

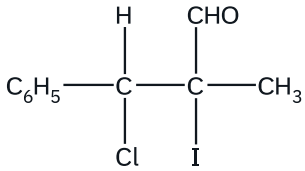


Organic products

- Major/most likely product



- Minor/least likely product



- Major/most likely product is formed from the most stable carbocation intermediate

OR – Cl is attached to carbon atom with the least hydrogens attached

OR the carbon with the most –C atoms attached

OR the – I is attached to the carbon atom with most hydrogens attached

---

Q85 · Alkenes and addition polymers · [1 mark]

Answer: **A**

One σ-bond and one π-bond

Q86 · Alkenes and addition polymers · [1 mark]

Answer: **A**

It is an electron pair acceptor.

Q87 · Alkenes and addition polymers · [1 mark]

Answer: **C**

$H_2C{=}CHCN$

Q88 · Alkenes and addition polymers · [16 marks]

OCR MARK SCHEME

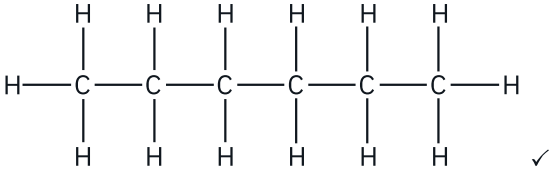
5(a)(i)

Product with H_2

EXAMINER GUIDANCE

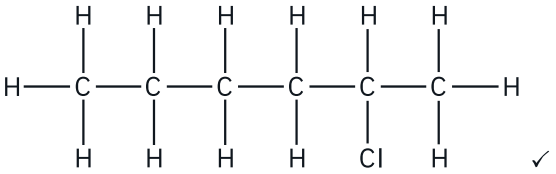
ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *part molecular formulae but not full*



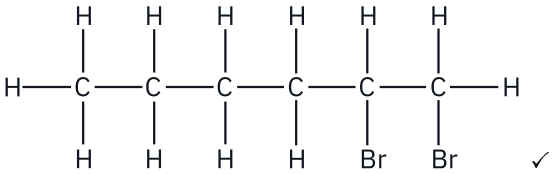
✓

Product with HCl



✓

Product with Br_2



✓

[3 marks]

5(a)(ii)

Nickel/Ni ✓

ALLOW *Pt* ***OR*** *Pd* ***OR*** *Rh*

[1 mark]

5(a)(iii)

(orange to) colourless

OR

bromine is decolourised ✓

ALLOW *'it decolourises / turns colourless'*

IGNORE *colour change*

[1 mark]

5(b)(i)

Level 3 (5–6 marks)

Calculates the correct mass of hexan-1-ol.

AND

Explains the purification steps, with most fine detail.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Attempts a calculation of the mass of hexan-1-ol which is partly correct.

OR

Outlines the purification steps, with some fine detail.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Attempts the calculation but makes little progress.

OR

Briefly outlines the purification steps, which may be incomplete.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

Indicative scientific points may include:

Calculation from moles

- n(hex-1-ene) = $\frac{4.20}{84.0}$ = 0.0500 (mol)
- n(hexan-1-ol) needed = 0.0500 × $\frac{100}{62.5}$ = 0.0800 (mol)
- mass needed = 0.0800 × 102 = 8.16 g
- **OR** volume $\frac{8.16}{0.82}$ = 9.95 cm^3

CHECK for extent of errors by **ECF**.

Calculation from mass

- Theoretical mass hex-1-ene = 4.20 × $\frac{100}{62.5}$ = 6.72 g
- Theoretical n(hex-1-ene) = $\frac{6.72}{84}$ = 0.0800 (mol)
- Mass of hexan-1-ol = 102 × 0.0800 = 8.16 g

0 marks

No response or no response worthy of credit.

[6 marks]

ALLOW *small slip/rounding errors such as errors on M_r (e.g. use of 83 instead of 84 for hex-1-ene M_r)*

Purification

- Use of a separating funnel to separate organic and aqueous layers
- Drying with an anhydrous salt
- Distillation

Fine detail

- Collection of upper layer (less dense from separating funnel)
- Example of drying agent, e.g. $MgSO_4$, $CaCl_2$
- Collection of fraction distilling at 63°C (boiling point of hex-1-ene)

Incorrect purification method **NOT** creditworthy

Examples of partly correct calculations

Mass = 5.1 g from 0.0500 × 102 *% yield omitted*

Mass = 3.1875 g from $0.0500 \times \frac{62.5}{100} \times 102$ *% yield inverted*

5(b)(ii)

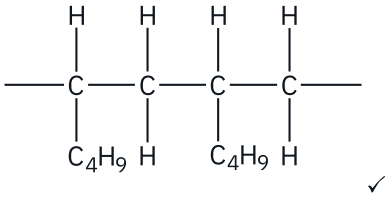
Yield of hex-1-ene is less ✓

A mixture of hex-1-ene and hex-2-ene forms ✓

[2 marks]

ALLOW *hex-2-ene also forms*

5(c)(i)



NOTE: *C_4H_9– is allowed for $CH_3CH_2CH_2CH_2$–*

[1 mark]

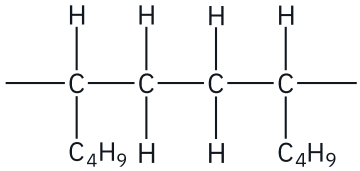
ALLOW *correct structural **OR** displayed **OR** skeletal formula*

Must show two repeat units

Polymer must have side links

IGNORE *brackets and use of 'n'*

ALLOW *alternating side chains, i.e.*



5(c)(ii)

Combustion for energy production ✓

for production of plastics

OR other useful organic compounds ✓

[2 marks]

For energy production,

ALLOW *generate electricity/heating*

ALLOW *as an (organic) feedstock*

Q89 · Alkenes and addition polymers · [1 mark]

Answer: **B**

3

Q90 · Alkenes and addition polymers · [21 marks]

OCR MARK SCHEME

19(a)(i)

Similarities

Orbital overlap

(sideways) overlap of p orbitals ✓

π bond

π bond/system/ring above and below (bonding (C) atoms/ring/plane) ✓

Difference

Kekule has: alternating π bonds OR 3 π bonds / localised (π electrons) / overlap in one direction / 2 electrons in π bond

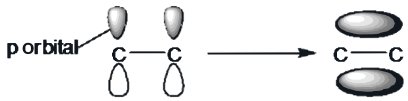
AND

Delocalised has: π ring (system) / all p orbitals overlap OR (π electrons) spread around ring / overlap in both directions / 6 electrons in π bond /

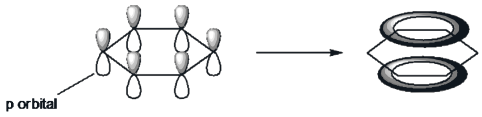
[3 marks]

EXAMINER GUIDANCE

ALLOW *diagram showing orbital overlap e.g.*



OR

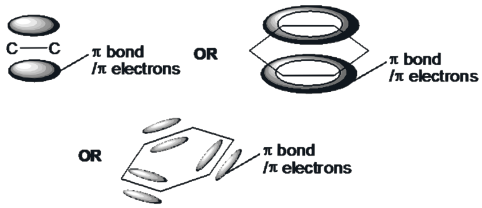


p orbital label is required for first mark

IGNORE *C=C in diagram showing π bond*

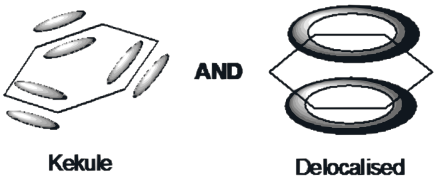
IGNORE *reference to s orbital overlap/σ bonds*

ALLOW *from labelled diagram showing π bond e.g.*



π bond/π electrons label is required for second mark

ALLOW *diagram showing π bond in both Kekule* ***AND*** *delocalised models e.g*



π bond labels not required for third mark

19(a)(ii)

Any 2 pieces of evidence from (✓ ✓)

Bond length

(C–C) bond length is between single (C–C) and double bond (C=C)

OR all (C–C) bond lengths are the same

Δ*H* hydrogenation

Δ*H* hydrogenation less (exothermic) than expected

Resistance to reaction

Benzene is less reactive than alkenes

OR bromination of benzene requires a catalyst/halogen carrier

OR benzene does not react with/decolourise bromine (at room temperature)

OR benzene reacts by substitution

OR benzene does not (readily) react by addition

ALLOW *(C–C) bond enthalpy is between single (C–C) and double bond (C=C)*

OR all (C–C) bond enthalpies are the same

IGNORE *enthalpy of hydration*

Benzene is unreactive is not sufficient

(no comparison to alkene)

For halogen carrier,

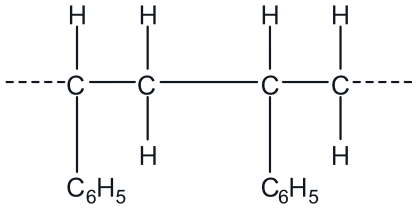
ALLOW *name or formula of suitable catalyst*

e.g. Fe, $AlCl_3$, $FeBr_3$

[2 marks]

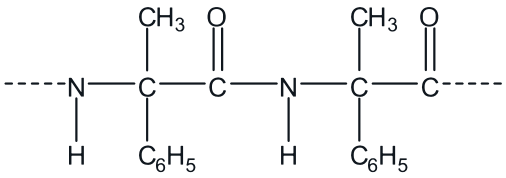
19(b)(i)

Polymer from D



✓

Polymer from E



Amide link ✓

2 repeat units of correct polymer ✓

[3 marks]

For BOTH structures,

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

'End bonds' MUST be shown

BUT ALLOW ECF IF end bonds omitted in both structures

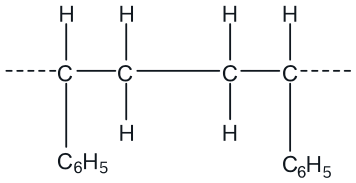
DO NOT ALLOW *more than 2 repeat units BUT ALLOW ECF in subsequent structure*

IGNORE *connectivity of* C_6H_5

CARE: **ALLOW** any consistent repeat unit:

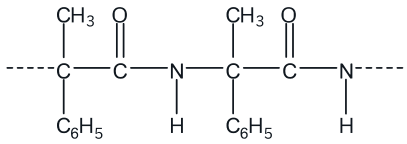
C_6H_5 and H groups can alternate or be on opposite sides of chain

e.g.



end –NH– may be at either side

e.g.



IGNORE *brackets*

IGNORE *n*

19(b)(ii)

D Addition / polyalkene

AND

E: Condensation / polyamide ✓

[1 mark]

DO NOT ALLOW *'additional'*

19(b)(iii)

Formation of electrophile

$CH_3COCl + AlCl_3 \rightarrow CH_3–C^+=O + AlCl_4^-$ ✓

Mechanism

Curly arrow from π-bond to $CH_3C^+=O$ ✓

ALLOW *'+' charge anywhere on* CH_3C^+O

i.e. CH_3CO^+

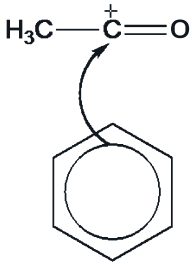
NOTE*: curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

1st curly arrow must

- go to the C of C=O

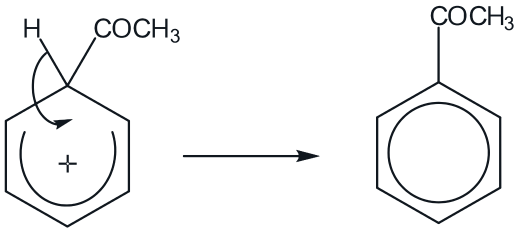
AND

- start from, **OR** close to circle of benzene ring



Correct intermediate ✓

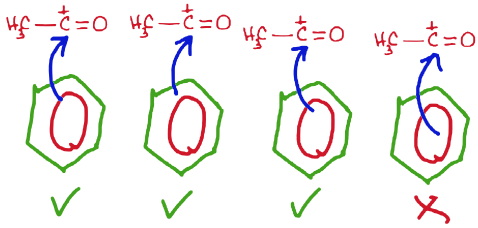
Curly arrow from C–H bond to reform π-ring ✓



Regeneration of catalyst

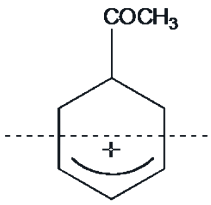
$H^+ + AlCl_4^- \rightarrow AlCl_3 + HCl$ ✓

[5 marks]



IGNORE *curly arrow shown on C=O*

DO NOT ALLOW *the following intermediate:*



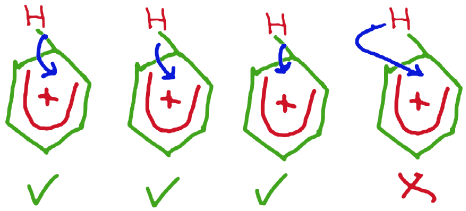
π-ring should cover approximately 4 of the 6 sides of the benzene ring structure

AND

the correct orientation, i.e. gap towards C with $COCH_3$

ALLOW *+ sign anywhere inside the 'hexagon' of intermediate*

curly arrow must start from, **OR** be traced back to, any part of C-H bond and go inside the 'hexagon'



19(b)(iv)

one mark for each correct structure/reagent

ALLOW *any vertical bond to the OH* ***OR*** *NH_2 groups*

e.g. **ALLOW**



DO NOT ALLOW *OH^-,* ***OR*** *NH_2^- but* ***ALLOW ECF*** *for subsequent use in this part*

For elimination,

IGNORE *'concentrated', 'dilute' with acids*

BUT DO NOT ALLOW H_2O/steam/(aq)

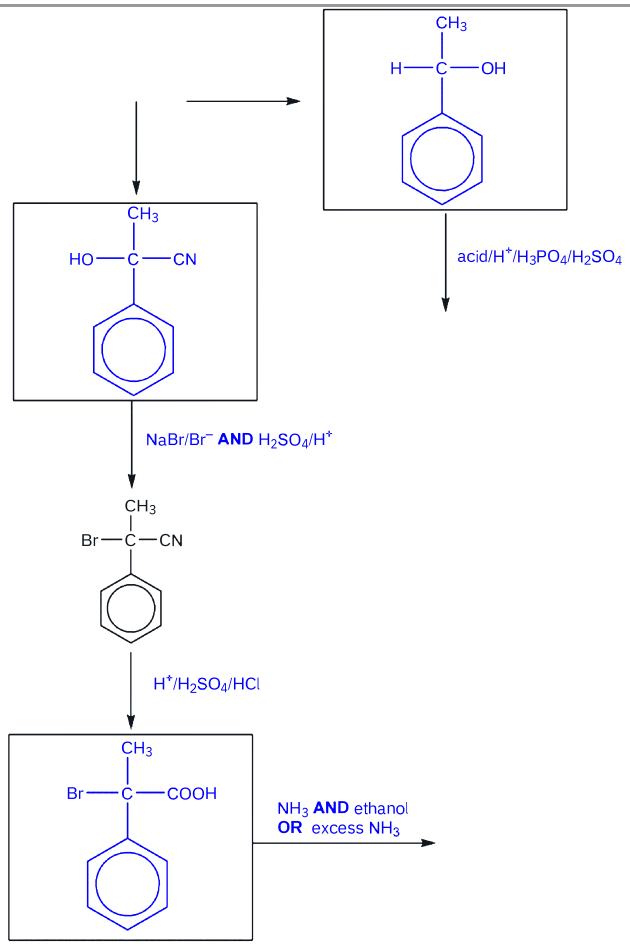
ALLOW *HBr for NaBr/H_2SO_4*

For hydrolysis.

IGNORE *missing (aq)*

ALLOW *HNO_3 for hydrolysis but*

DO NOT ALLOW *'HNO_3 and H_2SO_4'*

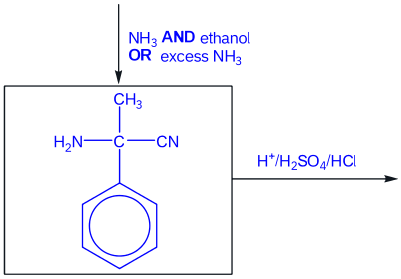


✓✓✓✓✓✓✓

[7 marks]

ALLOW *final 2 stages in opposite order*

i.e. NH_3 before acid hydrolysis



Q91 · Alkenes and addition polymers · [1 mark]

Answer: **C**

OCR MARK SCHEME

E-

EXAMINER GUIDANCE

ALLOW *E (This is the correct term)*

Q92 · Alkenes and addition polymers · [1 mark]

Answer: **D**

Types of bond broken: σ and π · Types of bond formed: σ

Q93 · Alkenes and addition polymers · [18 marks]

OCR MARK SCHEME

4(a)(i)

4-chloro-3,5-dimethylphenol ✓

CARE: Look for dimethyl

[1 mark]

EXAMINER GUIDANCE

ALLOW *3,5-dimethyl-4-chlorophenol*

ALLOW *absence of hyphens or extra hyphen or space, e.g. 4 chloro 3,5 dimethylphenol*

ALLOW *full stops or spaces between numbers e.g. 4-chloro-3.5-dimethylphenol*

ALLOW *name based on benzene, if unambiguous e.g.1-chloro-4-hydroxy-2,6-dimethylbenzene*

DO NOT ALLOW *meth* ***OR*** *methy*

4(a)(ii)

5 ✓

[1 mark]

4(a)(iii)

Functional group

Phenol ✓

Test

Indicator/pH paper turns red / orange **OR** pH < 7

OR pH meter < 7

AND

No reaction with Na_2CO_3/CO_3^{2-}/carbonate ✓

DO NOT ALLOW *alcohol* ***OR*** *hydroxide*

IGNORE *hydroxyl* ***OR*** *hydroxy*

IGNORE *OH (name asked for)*

ALLOW *Add bromine* ***AND*** *white precipitate*

ALLOW *$FeCl_3$* ***AND*** *violet/blue colour*

[2 marks]

4(a)(iv)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF *answer = 1.71×10^{-10},*

award FOUR calculation marks

CARE Separate mark for equation

Equation (1 mark)

$C_8H_9ClO \rightleftharpoons H^+ + C_8H_8ClO^-$ ✓

Molecular formulae required (atoms in any order)

$[C_8H_9ClO]$ calculation (2 marks)

Molar mass C_8H_9ClO = 156.5 (g mol^{-1}) ✓

ONLY correct answer

$[C_8H_9ClO] = \dfrac{4.8 \times 10}{156.5}$ **OR** 0.3067..... (mol dm^{-3}) ✓

Subsumes mark for molar mass = 156.5

K_a calculation (2 marks)

$[H^+] = 10^{-5.14} = 7.244..... \times 10^{-6}$ (mol dm^{-3}) ✓

$K_a = \dfrac{(7.244.... \times 10^{-6})^2}{0.3067.....} = 1.71 \times 10^{-10}$ (mol dm^{-3}) ✓

ALLOW *→ for ⇌*

DO NOT ALLOW *C_8H_8ClOH in equation*

i.e. $C_8H_8ClOH \rightleftharpoons H^+ + C_8H_8ClO^-$

If equation is omitted,

ALLOW *equation mark for a correct K_a expression with molecular formula*

i.e. $\dfrac{[H^+]\,[C_8H_8ClO^-]}{[C_8H_9ClO]}$

NO ECF from an incorrect formula in equation

ALLOW ECF *from incorrect molar mass*

ALLOW *0.307 up to calculator value: 0.306709265 correctly rounded*

ALLOW *7.24×10^{-6} up to calculator value: $7.244359601 \times 10^{-6}$ correctly rounded*

ALLOW 2 SF *($1.7.... \times 10^{-10}$) up to calculator value, correctly rounded (but take care from acceptable intermediate rounding)*

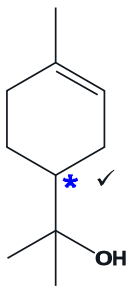
COMMON ERRORS

$2.36..... \times 10^{-5}$ 3/4 calculation marks

No squaring of 7.24×10^{-6}

[5 marks]

4(b)(i)



✓

DO NOT ALLOW *more than one **

ALLOW *a circle for **

[1 mark]

4(b)(ii)

MAXIMUM OF 4 MARKS FROM 5 MARKING POINTS

Requirement for *E*/*Z* isomerism 2 marks

C=C/double bond ✓

Each C (in C=C) is attached to (two) different groups/atoms ✓

IGNORE *no H attached to C=C*

IGNORE *functional',*

i.e. **ALLOW** different functional groups

ALLOW *in context of groups with largest atomic number*

Identification as *E*- or *Z*- isomer 2 marks

E/*Z* isomerism linked to (high) priority groups ✓

***Z*- isomer AND** groups are on same side

OR the ring carbons ✓

Reason why other *E*/*Z* isomer does not exist 1 mark

ring would be strained

OR ring would break/deform

OR Cannot form ring if high priority groups are on opposite sides

OR ring locks groups on one side of C=C bond ✓

[4 marks]

ORA

Award BOTH identification marks for:

Z- isomer **AND** (high) priority groups on same side

Mark independently of previous part

Response MUST be linked to the ring/cyclic structure

IGNORE *just 'E isomer is impossible'*

IGNORE *C=C bond cannot rotate*

IGNORE *Groups can't swap sides*

4(b)(iii)

First group:

Reagent

AND

Functional group: Alkene **OR** cycloalkene ✓

Examples of reagents

Br_2 or other halogen, HBr, H_2 **AND** Ni (catalyst), H_2O(g)/steam **AND** H^+ (catalyst)

Organic product for reagent with C=C in α-terpineol ✓

ALLOW *product from H_2 or H_2O if H^+ catalyst has been omitted from reagent.*

Second group

Reagent

AND

Functional group: (Tertiary) alcohol ✓

Examples of reagents

$NaBr/KBr/Br^-$ **AND** acid/H^+ (substitution),

OR HBr

Acid/H^+ (catalyst) (elimination),

CH_3COOH **AND** acid/H^+ (catalyst) (esterification)

$CH_3COOCOCH_3$ (esterification)

CH_3COCl (esterification)

Organic product for reagent with OH in α-terpineol ✓

ALLOW *product if catalyst omitted from reagent*

[4 marks]

ALLOW GROUPS EITHER WAY ROUND IN BOXES

Functional group MUST be named

DO NOT ALLOW *UV with halogens*

ALLOW *H_2SO_4/H_3PO_4/acid for H^+*

ALLOW *addition of HBr/ H_2O either way across C=C*

ALLOW ANY HALIDE*, i.e. Cl^-, Br^-, I^-*

ALLOW *H_2SO_4/H_3PO_4/acid for H^+*

ALLOW *HBr for H^+ and Br^-*

ALLOW *name or formula of any carboxylic acid or acyl chloride for esterification*

ALLOW *Na → product with –ONa* ***OR*** *$–O^-$*

DO NOT ALLOW *$Cr_2O_7^{2-}/H^+$ (tertiary alcohol)*

Q94 · Alkenes and addition polymers · [1 mark]

Answer: **D**

Q95 · Alkenes and addition polymers · [8 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

21(a)(i)

3,3-dimethylbut-1-ene ✓

CARE: Look for dimethyl

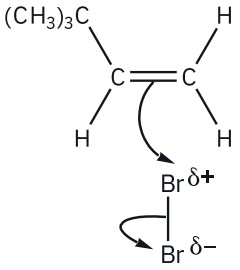
[1 mark]

__IGNORE__ lack of hyphens, or addition of commas or spaces

ALLOW full stops or spaces between numbers e.g. 3.3 dimethyl but-1-ene

DO NOT ALLOW meth OR methy

21(a)(ii)



1st curly arrow (from ANY alkene)

Curly arrow from double bond to Br of Br–Br ✓

DO NOT ALLOW partial charge on C=C

2nd curly arrow

Correct dipole on Br–Br

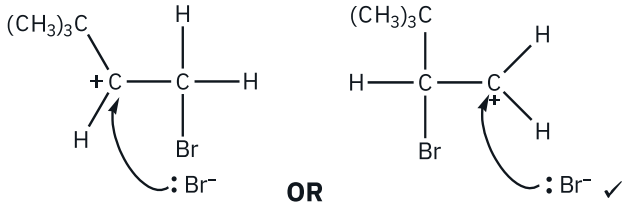
AND curly arrow for breaking of Br–Br bond ✓

3rd curly arrow

Correct carbocation with + charge on C with 3 bonds

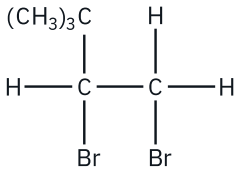
AND curly arrow from Br^- to C^+ of carbocation

DO NOT ALLOW δ+ on C of carbocation



i.e. ALLOW carbonium + on either C atom

Correct product to match mechanism/intermediate ✓



DO NOT ALLOW half headed or double headed arrows but allow __ECF__ if seen more than once

Name of mechanism: Electrophilic addition ✓

[5 marks]

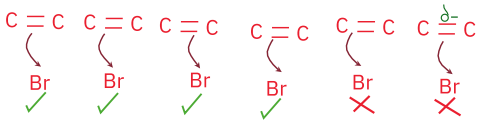
For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples):

1st curly arrow must

- go to a Br atom of Br–Br

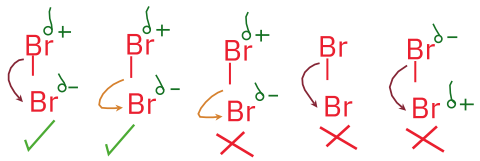
AND

- start from, OR be traced back to any point across width of C=C



2nd curly arrow must

- start from, OR be traced back to, any part of δ^+Br–Brδ^- bond
- AND go to Br δ^-



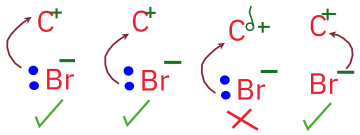
__IGNORE__ connectivity of CH_3 groups in carbocation and product and ALLOW C_4H_9

3rd curly arrow must

- go to the C^+ of carbocation

AND

- start from, OR be traced back to any point across width of lone pair on :Br^-
- OR start from – charge on Br^- ion



(Lone pair NOT needed if curly arrow shown from – charge on Br^-)

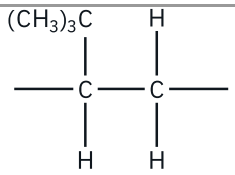
ALLOW bromonium ion

ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

__NOTE__: For a mechanism with HBr, ALLOW all marks EXCEPT for final product mark

21(b)(i)

For repeat unit,



Correct polymer with side links ✓

[1 mark]

- 'side bonds' required on either side of repeat unit from C atoms
- ALLOW more than one repeat unit
- ALLOW C_4H_9 for $C(CH_3)_3$

IGNORE *brackets*

- **IGNORE** *n*

IGNORE *connectivity of* $C(CH_3)_3$ *group*

21(b)(ii)

Advantage:

Energy/electricity (produced)

AND

Disadvantage:

CO_2 produced

OR gases causing global warming/climate change

OR greenhouse gases, e.g CO_2

BOTH advantage and disadvantage ✓

[1 mark]

ALLOW reduced use of fossil fuels

IGNORE *produced* CO_2 *and* H_2O

ALLOW less landfill / less harm to wildlife or environment (not just harmful)

ALLOW toxic/poisonous (waste) products/gases, e.g. CO

IGNORE *harmful/dangerous*

Q96 · Alkenes and addition polymers · [9 marks]

OCR MARK SCHEME

5(a)(i)

3-methylpentan-2-ol ✓

[1 mark]

EXAMINER GUIDANCE

IGNORE lack of hyphens or addition of commas

ALLOW *3-methylpentane-2-ol*

DO NOT ALLOW

2-methylpentan-3-ol

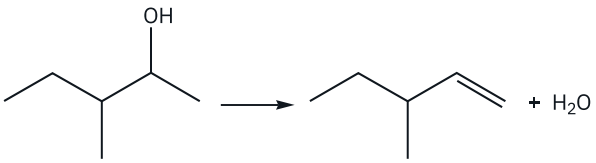
3-methylpent-2-ol

3-methpentan-2-ol

3-methypentan-2-ol

3-methlypentan-2-ol

5(a)(ii)



Correct structure of organic product ✓

Balanced equation ✓

[2 marks]

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

DO NOT ALLOW *additional reactants such as* H^+ *or [O] in the equation.*

ALLOW *incorrect isomer 3-methylpent-2-ene for balancing mark.*

5(a)(iii)

Priority groups on same side ✓

High(est) priority groups are CH_3CH_2 and CH_3

OR

Low(est) priority groups are CH_3 and H ✓

[2 marks]

ALLOW *suitable alternatives to 'priority' e.g. Groups with highest atomic number or more important groups etc.*

ALLOW *priority groups are both on the top*

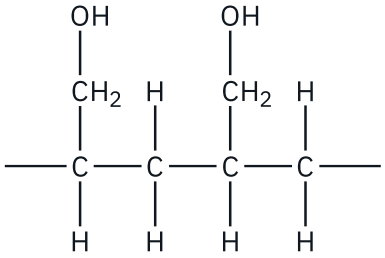
IGNORE references to relative mass of groups, Ar, M_r,

ALLOW *identification by name e.g. ethyl and methyl, or by circling on the structure.*

***IF** 'priority' is not mentioned **ALLOW** 1 mark for CH_3CH_2 and CH_3 are on same side OR H and CH_3 are on same side*

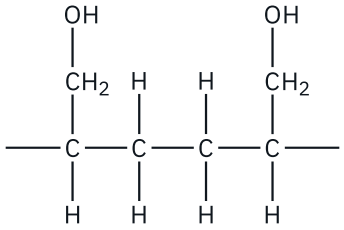
5(b)(i)

Section of polymer



***ALLOW** correct structural OR displayed OR skeletal formula.*

***ALLOW** alternating side chains i.e.*



✓

IGNORE brackets and use of 'n'

IGNORE incorrect connectivity for -CH_2OH

***DO NOT ALLOW** -HO*

- -

Reason for solubility in water

OH/alcohol groups form hydrogen bonds with water ✓

End bonds MUST be shown (solid or dotted)

***DO NOT ALLOW** one repeat unit*

Question asks for 2 repeat units.

[2 marks]

- -

***DO NOT ALLOW** 'it forms hydrogen bonds'*

5(b)(ii)

Any two ✓✓

- Recycled (to make other plastic materials)
- Combustion to generate energy / electricity
- As (organic) feedstock

IGNORE Reused

***ALLOW** Used as a fuel to generate energy / electricity*

[2 marks]

Q97 · Alkenes and addition polymers · [1 mark]

Answer: **C**

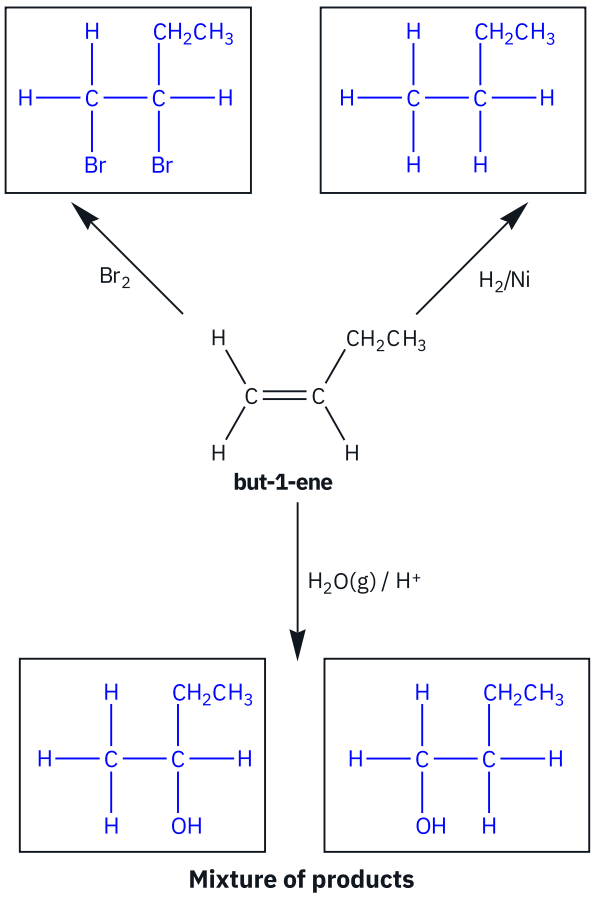
The monomer is $H_3CCH{=}CHCl$.

Q98 · Alkenes and addition polymers · [10 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

5(a)



one mark for each correct structure ✓✓✓✓

[4 marks]

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

DO NOT ALLOW *structure if H(s) are missing from ONE structural formula*

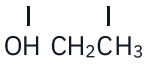
..... BUT **ALLOW** any further omissions as **ECF**

Take care with numbers of carbons

IGNORE *connectivity,*

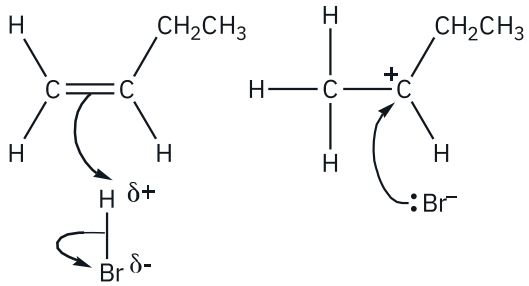
e.g.

ALLOW



But **DO NOT ALLOW** –HO

5(b)(i)



1st curly arrow (from ANY alkene)

Curly arrow from double bond to H of H–Br ✓

DO NOT ALLOW *partial charge on C=C*

2nd curly arrow

Correct dipole on H–Br

AND curly arrow for breaking of H–Br bond ✓

3rd curly arrow

Correct carbocation with + charge on C

AND curly arrow from Br^- to C+ of carbocation ✓

DO NOT ALLOW *δ+ on C of carbocation*

Correct product (independent mark) ✓

Throughout,

ALLOW *any combination of skeletal OR structural OR displayed formula as long as unambiguous*

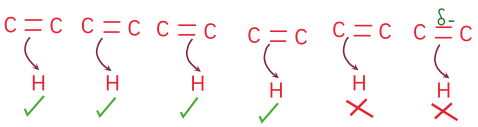
For curly arrows,

ALLOW *straight or snake-like arrows and small gaps (see examples)*

DO NOT ALLOW *half headed or double headed arrows but allow* ***ECF*** *if seen more than once*

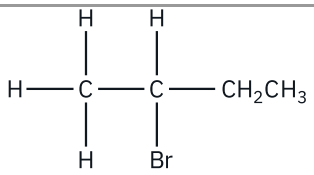
1st curly arrow must

- go to a H atom of H–Br
- **AND**
- start from, OR be traced back to any point across width of C=C



2nd curly arrow must

- start from, OR be traced back to, any part of $^{\delta+}$H–Br$^{\delta-}$ bond



[4 marks]

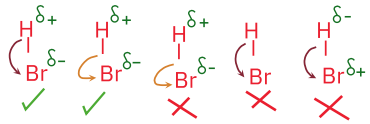
5(b)(ii)

(major product forms from) most/more stable intermediate/carbocation ✓

(major product forms from a) secondary carbocation OR carbocation bonded to more C atoms / more alkyl groups OR carbocation bonded to fewer H atoms ✓

[2 marks]

- **AND** go to $Br^{\delta-}$



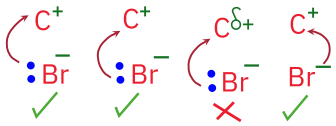
ALLOW ECF for 2nd and 3rd curly arrow marking points if used Br_2 instead of HBr

3rd curly arrow must

- go to the C^+ of carbocation

AND

- start from, OR be traced back to any point across width of lone pair on $:Br^-$
- OR start from – charge on Br^- ion



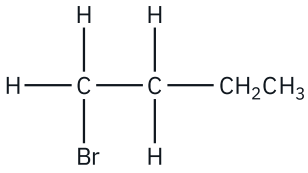
(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)

IGNORE *connectivity of alkyl groups in carbocation and product*

IF *drawn both intermediates and products with no labelling*

ALLOW *3rd curly arrow mark BUT* ***NOT*** *product mark, unless clearly labelled as'2-bromobutane' or 'major' product*

ALLOW ECF for product from incorrect carbocation. e.g. 1-bromobutane:



ALLOW *carbonium ion for carbocation*

IGNORE *descriptions of the major/minor product in terms of Markownikoff's rule*

e.g. H atom joins to C with most H

IGNORE *references to stability of the product*

ALLOW ORA

Q99 · Alkenes and addition polymers · [6 marks]

OCR MARK SCHEME

19

Level 3 (5–6 marks)

Describes addition reactions including the mechanisms of one alkene AND one carbonyl compound AND some additional details

EXAMINER GUIDANCE

Indicative scientific points may include:

Reaction of alkene and mechanism

- Suitable reaction, e.g. alkene and Br_2 OR X_2 OR HX OR H_2O OR H_2 OR polymerisation

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Describes an addition reaction including the mechanism of one alkene OR one carbonyl compound AND some additional details

OR

Describes addition reactions including an attempt to give the mechanisms of one alkene AND one carbonyl compound

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Selects suitable reagents for addition reactions of one alkene AND one carbonyl compound.

OR

Attempts to describe an addition reaction including an attempt to give the mechanism of one alkene OR one carbonyl compound.

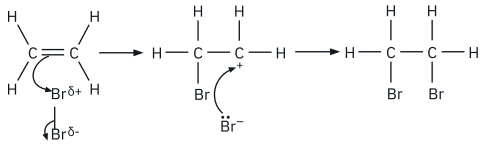
There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

May be shown within mechanism

- Mechanism, e.g.



ALLOW *mechanism for H_2 AND H_2O to be shown as electrophilic addition even though incorrect - consider impact on communication statement.*

ALLOW *suitable non-specification alternative e.g. HCN*

Additional details (**NOT** INCLUSIVE)

- Electrophilic addition
- Systematic names of reactants and/or products
- Details of functional group interconversion e.g. alkene to dibromo
- Details on reagents required e.g.

- H_2 with Ni Catalyst

- $H_2O(g)$ with H_3PO_4 catalyst

- Explanation of major and minor product from electrophilic addition of HX with unsymmetrical alkene
- Explanation of carbocation intermediate stability
- Heterolytic fission

Reaction of carbonyl compound and mechanism

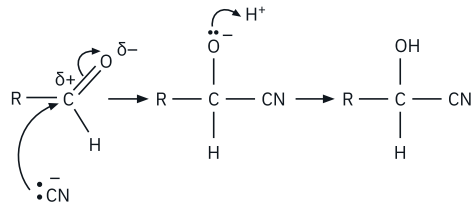
Suitable reactions, e.g.

- Aldehyde or ketone and HCN OR H^-

e.g. RCHO + HCN → RCH(OH)CN

May be shown within mechanism

- Mechanisms, e.g.



OR H_2O instead of H^+ for 2nd stage

ALLOW *suitable non-specification alternative e.g. H_2O, NH_3, 1° amine*

IGNORE *reactions with carboxylic acids (or derivatives) i.e. addition-elimination mechanism (condensation reaction)*

Additional details (**NOT** INCLUSIVE)

- Nucleophilic addition

- Systematic names of reactants and/or products
- Details of functional group interconversion e.g. aldehyde to hydroxynitrile
- In reduction, aldehydes form 1° alcohols and ketones form 2° alcohols
- Details on reagents required e.g.

- formation of hydroxynitriles with $NaCN/H^+(aq)$

- formation of alcohols with $NaBH_4$

- Heterolytic fission

Aspects of the communication statement being met might typically include:

- Curly arrows starting from lone pairs / negative charges / bonds.
- All reactants and intermediates have relevant charges and dipoles.
- Mechanisms given are chemically feasible for the reactions.
- No additional incorrect reactants have been included.

Q100 · Alkenes and addition polymers · [1 mark]

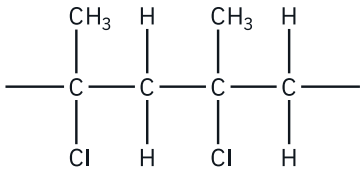
Answer: **C**

The bond enthalpy of C–C σ bonds is **higher** than that of π bonds.

Q101 · Alkenes and addition polymers · [9 marks]

OCR MARK SCHEME

24(a)(i)



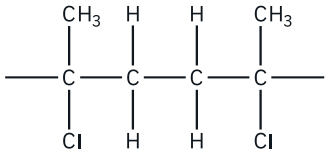
Two correct repeat units for 2-chloropropene (*n* and brackets not required) ✓

[1 mark]

EXAMINER GUIDANCE

ALLOW *structural* ***OR*** *displayed* ***OR*** *skeletal formula* ***OR*** *mixture of the above (as long as unambiguous)*

ALLOW*:*



.....but CH_3 and Cl must be on same C atom

CH_3 and Cl can be shown either side of the structure

NOTE*: 'side bonds' ARE required on either side of repeat unit from C atoms*

IGNORE *connectivity of methyl group*

IGNORE *brackets*

IGNORE *n or subscript numbers*

24(a)(ii)

Formation of HCl/hydrochloric acid/ **OR** chlorine

ALLOW *Cl or* Cl_2 *for chlorine*

[1 mark]

ALLOW *produces CO (from incomplete combustion)*

IGNORE *toxic waste products*

Response must reflect chlorine or carbon monoxide in some way

24(b)

$C_5H_{10} + 7½\ O_2 \rightarrow 5CO_2 + 5H_2O$ ✓

ALLOW $2C_5H_{10} + 15O_2 \rightarrow 10CO_2 + 10H_2O$

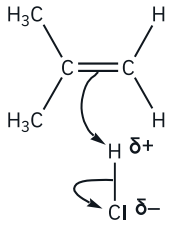
IGNORE *state symbols (even if incorrect)*

[1 mark]

24(c)(i)

Curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows

1. Curly arrow from C=C to HCl and H–Cl 2 marks



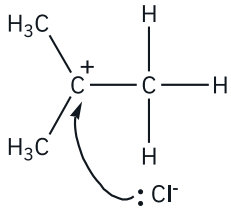
Curly arrow from C=C bond to H of H–Cl ✓

DO NOT ALLOW *partial charge on C=C*

Correct dipole shown on H–Cl

AND curly arrow that breaks H–Cl bond ✓

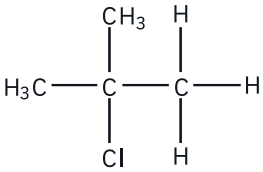
2. Curly arrow from Cl^- to carbocation 1 mark



Curly arrow from Cl^- to C^+ of carbocation (carbocation must follow structure from step 1 i.e. 2 methyl groups) ✓

DO NOT ALLOW *δ+ on C of carbocation*

3. Product 1 mark



✓

4. Name of mechanism 1 mark

Electrophilic addition ✓

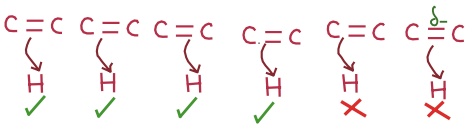
[5 marks]

1st curly arrow must

- go to the H atom of H–Cl

AND

- start from, **OR** be traced back to any point across width of C=C

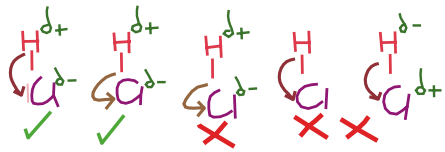


2nd curly arrow must

- start from, **OR** be traced back to any part of $^{\delta+}H–Cl^{\delta-}$ bond

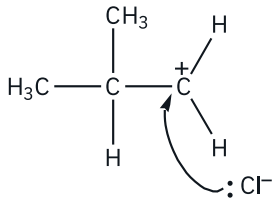
AND

- go to $Cl^{\delta-}$



Use of Cl-Cl or H-Br loses first marking point but gains **ECF** for second marking point

ALLOW formation of minor carbocation, i.e.



(formation of major product assessed below)

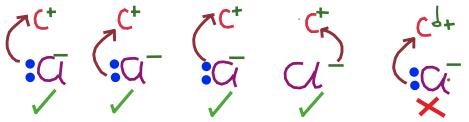
ALLOW ECF from use of Cl_2 OR HBr

3rd curly arrow must

- go to the C+ of carbocation

AND

- start from, **OR** be traced back to any point across width of lone pair on $:Cl^-$
- **OR** start from – charge of Cl^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge of Cl^- ion)

ALLOW ECF *for correct tertiary product following use of HBr ONLY (i.e. Cl in structure shown replaced with Br)*

24(c)(ii)

More stable (tertiary) carbocation is formed as intermediate

OR

The minor product forms a less stable (primary) carbocation ✓

NOTE must refer to stability of carbocation

IGNORE *references to Markownikoff's rule*

IGNORE *secondary*

[1 mark]

Q102 · Alkenes and addition polymers · [1 mark]

Answer: **D**

OCR MARK SCHEME

8

EXAMINER GUIDANCE

ALLOW *8*

Q103 · Alkenes and addition polymers · [1 mark]

Answer: **C**

$H^{\delta+}$—$Br^{\delta-}$ acts as an electrophile.

Q104 · Alkenes and addition polymers · [1 mark]

Answer: **A**

E-3-bromopent-2-ene

Q105 · Alkenes and addition polymers · [1 mark]

Answer: **B**

A σ-bond is stronger than a π-bond.

Q106 · Alkenes and addition polymers · [1 mark]

Answer: **D**

Q107 · Alkenes and addition polymers · [1 mark]

Answer: **B**

OCR MARK SCHEME

4

EXAMINER GUIDANCE

ALLOW *4*

Q108 · Alkenes and addition polymers · [1 mark]

Answer: **A**

Q109 · Alkenes and addition polymers · [10 marks]

OCR MARK SCHEME

24(a)

Curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows

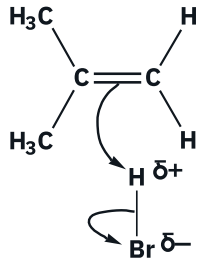
EXAMINER GUIDANCE

1st curly arrow must

- go to the H atom of H–Br

AND

1. Curly arrow from C=C to HBr and H–Br 2 marks



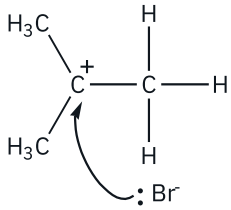
DO NOT ALLOW *partial charge on C=C*

Curly arrow from C=C bond to H of H–Br ✓

Correct dipole shown on H–Br

AND curly arrow that breaks H–Br bond ✓

2. Curly arrow from Br^- to carbocation 1 mark



DO NOT ALLOW *δ+ on C of carbocation*

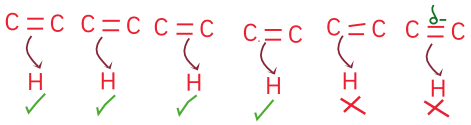
Correct carbocation **AND** curly arrow from Br^- to C^+ of CORRECT carbocation ✓

3. Name of mechanism 1 mark

Electrophilic addition ✓

[4 marks]

- start from, **OR** be traced back to any point across width of C=C

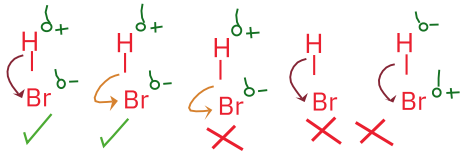


2nd curly arrow must

- start from, **OR** be traced back to any part of $^{\delta+}H–Br^{\delta-}$ bond

AND

- go to $Br^{\delta-}$

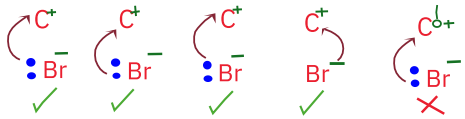


3rd curly arrow must

- go to the C+ of carbocation

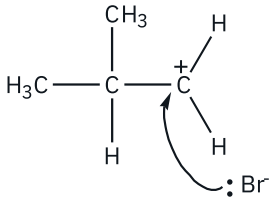
AND

- start from, **OR** be traced back to any point across width of lone pair on $:Br^-$
- **OR** start from – charge of Br^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge of Br^- ion)

DO NOT ALLOW incorrect carbocation, i.e.



24(b)(i)

Same molecular formula

AND

Different structural formulae ✓

[1 mark]

Same formula is not sufficient (no reference to molecular)

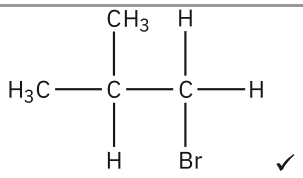
Different arrangement of atoms is not sufficient (no reference to structure/structural)

For structural formulae,

ALLOW *structure/displayed/skeletal formulae*

24(b)(ii)

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

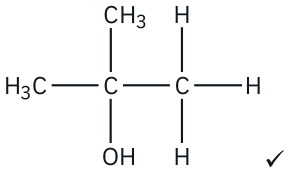


✓

[1 mark]

24(c)(i)

Alcohol C



✓

Reagent **AND** product

NaOH **AND** NaBr

OR

KOH **AND** KBr

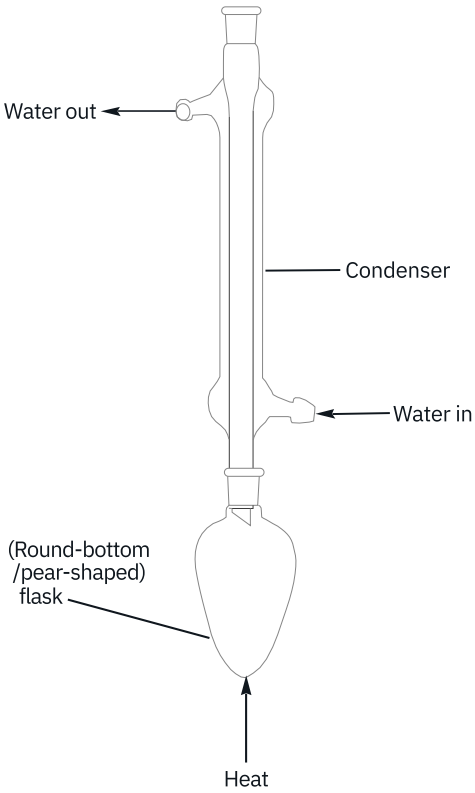
OR

OH^- **AND** Br^- ✓

[2 marks]

> ***ALLOW*** *Reagent: H_2O/water*
>
> **AND** Product: HBr

24(c)(ii)



1st mark:

Labelled condenser above a flask ✓

2nd mark:

Only available if 1st mark has been awarded

Flask **AND** heat labelled ✓

> For condenser label,
>
> ***ALLOW*** *'condenser'*
>
> **OR**
>
> water in **AND** water out (May be implied by connection to tap and sink).

[2 marks]

Q110 · Alkenes and addition polymers · [17 marks]

OCR MARK SCHEME

16(a)(i)

σ-bond: Overlap of orbitals between (bonding) atoms ✓

π-bond: Sideways overlap of (adjacent) p-orbitals ✓

[2 marks]

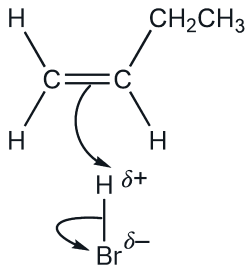
16(a)(ii)

σ-bonds: 9 ✓

π-bonds: 2 ✓

[2 marks]

16(b)(i)



Curly arrow from C=C bond to H of H–Br ✓

DO NOT ALLOW *partial charge on C=C*

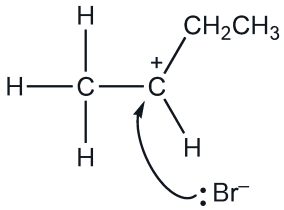
Correct dipole shown on H–Br

AND curly arrow showing breaking of H–Br bond ✓

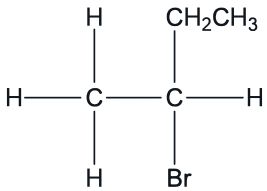
Correct carbocation

AND curly arrow from Br^- to C^+ of carbocation ✓

DO NOT ALLOW *δ+ on C of carbocation*



Correct product ✓



[4 marks]

EXAMINER GUIDANCE

ALLOW *labelled diagrams*

IGNORE *the type of orbital for σ-bond*

DO NOT ALLOW *pi-orbital*

NOTE*: curly arrows can be straight, snake like, etc.*

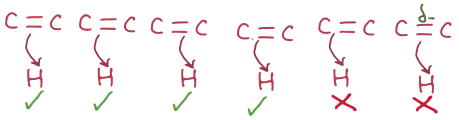
but **NOT** double headed or half headed arrows

1st curly arrow must

- go to the H atom of H–Br

AND

- start from, **OR** be traced back to any point across width of C=C

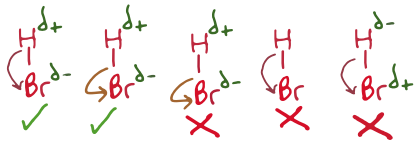


2nd curly arrow must

- start from, **OR** be traced back to any part of $^{\delta+}H–Br^{\delta-}$ bond

AND

- go to $Br^{\delta-}$



3rd curly arrow must

- go to the C+ of carbocation

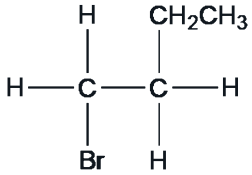
AND

- start from, **OR** be traced back to any point across width of lone pair on $:Br^-$
- **OR** start from – charge of Br^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge of Br^- ion)

ALLOW ECF *for product from incorrect carbocation, i.e.*



16(b)(ii)

(major product forms from) most/more stable intermediate/carbocation ✓

(major product forms from a) secondary carbocation

OR carbocation bonded to more C atoms / more alkyl groups

OR carbocation bonded to fewer H atoms ✓

[2 marks]

For carbocation,

ALLOW *carbonium ion or cation*

IGNORE *descriptions of the major/minor product in terms of Markownikoff's rule e.g. H atom joins to C with most H*

IGNORE *references to stability of the product*

ALLOW ORA*, i.e.*

(minor product forms from) least/less stable intermediate/carbocation ✓

(minor product forms from a) primary carbocation

OR carbocation bonded to less C atoms / less alkyl groups

OR carbocation bonded to more H atoms ✓

16(b)(iii)

3 ✓

[1 mark]

16(c)(i)

Same structural formula

AND

Different arrangement (of atoms) in space

OR different spatial arrangement (of atoms) ✓

[1 mark]

ALLOW *structure/displayed/skeletal formula*

DO NOT ALLOW *same empirical formula*

OR same general formula

IGNORE *same molecular formula*

Reference to *E*/*Z* isomerism or optical isomerism is not sufficient

16(c)(ii)

Student is not correct

AND

2 groups on one carbon atom (of C=C) are the same

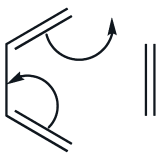
OR

C–C bond can rotate ✓

[1 mark]

DO NOT ALLOW *one side of C=C*

16(d)(i)



1 mark for each curly arrow ✓✓

IGNORE *any dipoles shown*

NOTE*: curly arrows can be straight, snake-like, etc.*

but **NOT** half headed or double headed arrows

Curly arrow from C=C bond must

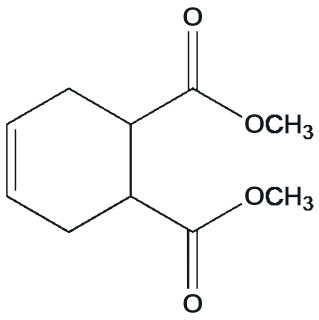
start from, **OR** be traced back to,

Lower left: any part of C=C bond and go to C–C

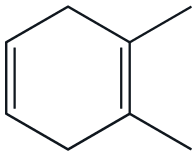
[2 marks]

Upper left: any part of C=C bond and go to gap between C=C and C=C

16(d)(ii)



✓



✓

[2 marks]

Q111 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

E and **G**

Q112 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

2,3-dichloro-2-methylbutane

Q113 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

$C_6H_{12}O_2$

Q114 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

3

Q115 · Basic concepts of organic chemistry · [15 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

5(a)

$C_nH_{2n}O_2$

OR

$C_nH_{2n+1}COOH$ ✓

[1 mark]

5(b)(i)

Tetrahedral

AND

109.5(°) ✓

Mark each point independently

ALLOW *range 109 – 110°*

IGNORE *surrounded by four atoms*

IGNORE *four areas of electron charge repel*

four bonded pairs repel **OR** four bonds repel ✓

[2 marks]

IGNORE *four electron pairs repel (one could be lp)*

DO NOT ALLOW *atoms repel*

5(b)(ii)

104.5(°) ✓

[1 mark]

ALLOW *range 104 – 105°*

5(c)

LOOK ON THE SPECTRUM for labelled peaks which can be given credit

C=O

1630 – 1820 (cm^{-1})

AND

C=O ✓

O–H

3200 – 3600 cm^{-1}

AND

O–H ✓

Any two structures of compound D from ✓✓

CH_3COCH_2OH

$CH_2(OH)CH_2CHO$

$CH_3CH(OH)CHO$

[4 marks]

ALLOW *wavenumber values that identify the peak within the range 1630 – 1820*

ALLOW *carbonyl* ***OR*** *aldehyde* ***OR*** *ketone for C=O*

ALLOW *wavenumber values that identify the peak within the range 3200 – 3600*

ALLOW *alcohol for O–H*

IGNORE *other bonds*

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above*

IGNORE *names*

Penalise incorrect connectivity once only

5(d)(i)

Ultraviolet (radiation)/UV ✓

[1 mark]

ALLOW *sunlight*

IGNORE *temperature*

5(d)(ii)

$CH_3CH_2COOH + Cl_2 \rightarrow CH_3CHClCOOH + HCl$ ✓

[1 mark]

ALLOW $C_2H_5COOH + Cl_2 \rightarrow C_2H_4ClCOOH + HCl$

ALLOW $C_3H_6O_2 + Cl_2 \rightarrow C_3H_5ClO_2 + HCl$

5(d)(iii)

one electron from the bond (pair) goes to each atom/chlorine/radical ✓

[1 mark]

ALLOW *the breaking of a covalent bond where each atom keeps one of the bonding electrons*

IGNORE *particle for atom*

ALLOW *one electron from the bond goes to each product / species*

DO NOT ALLOW *molecule or compound for atom*

IGNORE *homolytic fission equations*

5(d)(iv)

Propagation step 1

$Cl\bullet + CH_3CH_2COOH \rightarrow CH_3CHCOOH\bullet + HCl$ ✓

Propagation step 2

$CH_3CHCOOH\bullet + Cl_2 \rightarrow CH_3CHClCOOH + Cl\bullet$ ✓

[2 marks]

ALLOW

1. $Cl\bullet + C_3H_6O_2 \rightarrow C_3H_5O_2\bullet + HCl$
2. $C_3H_5O_2\bullet + Cl_2 \rightarrow C_3H_5ClO_2 + Cl\bullet$

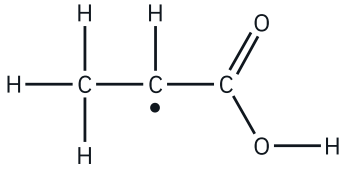
ALLOW *dot at any position on the radical*

ALLOW *1 mark if both equations correct but any dots omitted from radicals*

5(d)(v)

Dot shown in correct position

ALLOW *–OH*



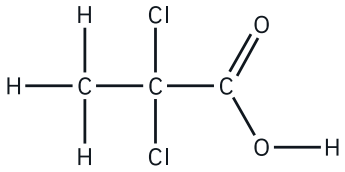
✓

[1 mark]

5(d)(vi)

Any structure with two or more Cl atoms on alkyl chain (provided that one Cl is at C–2)

e.g.



✓

[1 mark]

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above*

DO NOT ALLOW $C_3H_4Cl_2O_2$

ALLOW *further substitution into any or all of the 4 positions occupied by H atoms in the alkyl group, provided that at least one Cl is at C-2*

Q116 · Basic concepts of organic chemistry · [1 mark]

Answer: **A**

1, 2 and 3

Q117 · Basic concepts of organic chemistry · [1 mark]

Answer: **D**

Alicyclic and saturated

Q118 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

C_7H_{14}

Q119 · Basic concepts of organic chemistry · [1 mark]

Answer: **A**

$C_{10}H_8$

Q120 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

OCR MARK SCHEME

2

EXAMINER GUIDANCE

ALLOW *2 (This is the number of straight chain isomers with a chiral C atom)*

Q121 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

Q122 · Basic concepts of organic chemistry · [12 marks]

OCR MARK SCHEME

6(a)(i)

3-hydroxybutanal ✓

EXAMINER GUIDANCE

ALLOW *3-hydroxybutan-1-al*

IGNORE *lack of hyphens or addition of commas*

[1 mark]

ALLOW *4-oxobutan-2-ol* ***OR*** *1-oxobutan-3-ol*

DO NOT ALLOW

- 3-hydroxybutal
- 3-hydroxylbutanal

IGNORE *nucleophilic* ***OR*** *electrophilic* ***OR*** *radical*

DO NOT ALLOW *addition–elimination, condensation, polymerisation*

6(a)(ii)

Addition ✓

[1 mark]

6(a)(iii)

ALLOW *any formula provided that number and type of atoms and charge are correct,*

e.g. For CH_3CHO, **ALLOW** CH_3COH, C_2H_4O, etc.

Throughout, **IGNORE** 'connectivity in any formula or structures shown.

Examples in Answer column and in 6a(iv) guidance below

Step 1:

- Correct equation ✓
- One correct acid–base pair ✓

i.e. A1 and B1 **OR** A2 and B2

	CH_3CHO	+	OH^-	⇌	$^-CH_2CHO$	+	H_2O
OR	CH_3CHO	+	OH^-	⇌	CH_3CO^-	+	H_2O
	A1		**B2**		**B1**		**A2**
	OR						
	A2		**B1**		**B2**		**A1**

Step 1: ALLOW H^+ transfer from OH^-,

i.e.

CH_3CHO	+	OH^-	⇌	$CH_3CH_2O^+$
B2		**A1**		**A2**
OR				
B1		**A2**		**A1**

Step 2:

$CH_3CHO + {}^-CH_2CHO + H_2O \rightarrow CH_3CHOHCH_2CHO + OH^-$ ✓

For $^-CH_2CHO$: **ALLOW** CH_2CHO^-; CH_3CO^-; $C_2H_3O^-$

For $CH_3CHOHCH_2CHO$, **ALLOW** $C_4H_8O_2$

Step 2:

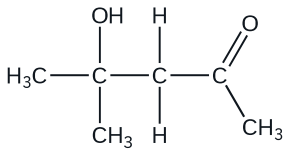
$CH_3CHO + CH_3CH_2O^+ + O^{2-} \rightarrow$

$CH_3CHOHCH_2CHO + OH^-$ ✓

For $CH_3CH_2O^+$: **ALLOW** CH_3CHOH^+, $C_2H_5O^+$

[3 marks]

6(a)(iv)



✓

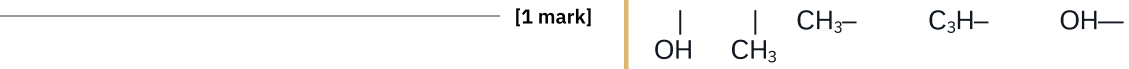
ALLOW *correct structural* ***OR*** *displayed*

OR skeletal formulae

OR a combination of above as long as unambiguous

For connectivity,

ALLOW



(Connectivity not being assessed)

[1 mark]

6(b)

Indicative scientific points may include:

Explanation of role of electrophiles in organic chemistry

Level 3 (5–6 marks)

Describes, in detail, electrophilic reactions and mechanisms of one aliphatic **AND** one aromatic compound.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Describes, in detail, an electrophilic reaction and mechanism of one aliphatic **OR** one aromatic compound.

OR

Describes electrophilic reactions and mechanisms of one aliphatic **AND** one aromatic compound, with few omissions/errors.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Selects suitable reagents for electrophilic reactions of one aliphatic **AND** one aromatic compound.

OR

Attempts to describe an electrophilic reaction and mechanism of one aliphatic **OR** one aromatic compound, with omissions/errors.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks *No response or no response worthy of credit.*

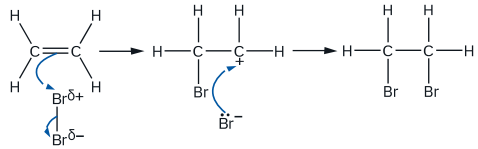
[6 marks]

Reaction of aliphatic compound and mechanism

- Suitable reaction, e.g. ethene and Br_2

May be shown within mechanism

- Mechanism, e.g.

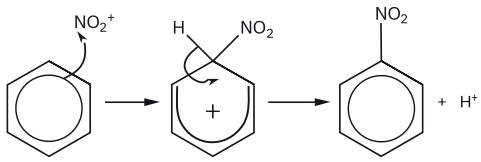


Reaction of aromatic compound and mechanism

- Suitable reaction, e.g. benzene + Cl_2 ; HNO_3

May be shown within mechanism

- Mechanism, e.g.



Examples of a detailed description (NOT INCLUSIVE)

- Electrophile as electron pair acceptor
- Types and names of mechanisms
- Equations for generation of electrophile and regeneration of catalyst
- Accurately positioned and directed curly arrows and charges/ dipoles included
- Explanation of major and minor product from electrophilic addition

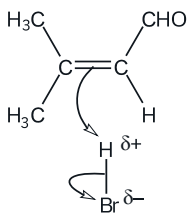
Q123 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

Q124 · Basic concepts of organic chemistry · [15 marks]

OCR MARK SCHEME

16(a)(i)



Curly arrow from C=C bond to H of H–Br ✓

DO NOT ALLOW *partial charge on C=C*

Correct dipole shown on H–Br

AND curly arrow showing breaking of H–Br bond ✓

Correct carbocation

EXAMINER GUIDANCE

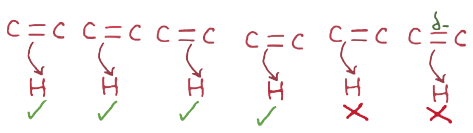
NOTE*: curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

1st curly arrow must

- go to the H atom of H–Br

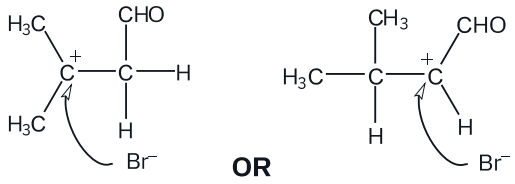
AND

- start from, **OR** be traced back to any point across width of C=C

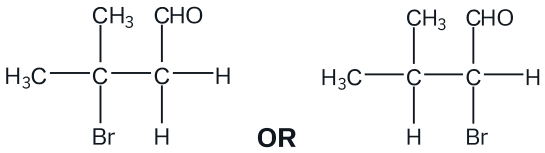


AND curly arrow from Br^- to C^+ of carbocation ✓

DO NOT ALLOW *δ+ on C of carbocation*



Correct product ✓



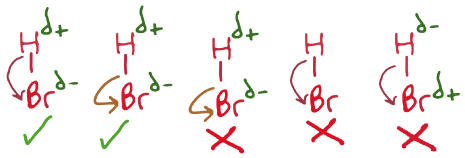
[4 marks]

2nd curly arrow must

- start from, **OR** be traced back to any part of $^{\delta+}H–Br^{\delta-}$ bond

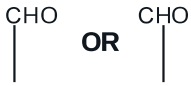
AND

- go to $Br^{\delta-}$



IGNORE *connectivity of CHO and CH_3 groups in carbocation and product*

e.g. **ALLOW**



ALLOW *COH for CHO (reaction does not involve this group)*

3rd curly arrow must

- go to the C+ of carbocation

AND

- start from, **OR** be traced back to any point across width of lone pair on $:Br^-$
- **OR** start from – charge of Br^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge of Br^- ion)

16(a)(ii)

(major product forms from) most/more stable intermediate/carbocation ✓

(major product forms from a) tertiary carbocation

OR carbocation bonded to more C atoms / more alkyl groups

OR carbocation bonded to no H atoms ✓

[2 marks]

For carbocation, **ALLOW** carbonium ion or cation

IGNORE *descriptions of the major/minor product in terms of Markownikoff's rule*

e.g. H atom joins to C with most H

IGNORE *references to stability of the product*

ALLOW ORA*, i.e.*

(minor product forms from) least/less stable intermediate/carbocation ✓

(minor product forms from a) secondary carbocation

OR carbocation bonded to fewer C atoms / more alkyl groups

OR carbocation bonded to H atoms ✓

16(b)(i)

ALLOW *ammoniacal silver nitrate* ***OR*** *Ag^+/NH_3*

Tollens' (reagent) ✓

Silver (mirror/precipitate/ppt/solid) with citronellal/the aldehyde ✓

[2 marks]

ALLOW *black ppt* ***OR*** *grey ppt*

IGNORE *references to acidified dichromate reacting with both compounds*

ALLOW *2,4-DNP/2,4-DNPH*

ALLOW Brady's reagent ✓

Yellow/orange/red precipitate with citronellal/aldehyde/carbonyl group ✓

16(b)(ii)

$C_{10}H_{18}O$ ✓

[1 mark]

DO NOT ALLOW $C_{10}H_{17}OH$

16(b)(iii)

Same molecular formula

AND

Different structural formulae ✓

OR

Both (geraniol and citronellal) have the molecular formula $C_{10}H_{18}O$

AND

Different structural formulae ✓

[1 mark]

Same formula is not sufficient

(no reference to molecular)

Different arrangement of atoms is not sufficient

(no reference to structure/structural)

For structural formulae,

ALLOW *structure/displayed/skeletal formulae/ functional groups*

DO NOT ALLOW *any reference to spatial/space*

ALLOW ECF *from incorrect molecular formula in (b)(ii)*

16(b)(iv)

Same structural formula

AND

Different arrangement (of atoms) in space

OR different spatial arrangement (of atoms) ✓

[1 mark]

ALLOW *structure/displayed/skeletal formula*

DO NOT ALLOW *same empirical formula*

OR same general formula

IGNORE *same molecular formula*

Reference to *E*/*Z* isomerism or optical isomerism is not sufficient

16(b)(v)

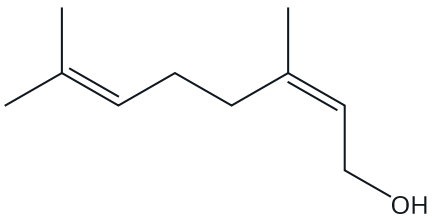
Geraniol:

(Carbon-carbon) double bond at carbon-2(,3)

AND

E **OR** *Z* ✓

Structure of *Z* geraniol (*E* isomer is shown in question)



✓

Citronellal:

chiral/asymmetric C at carbon-3

OR carbon-3 is bonded to 4 different groups

AND

CHECK diagrams of citronellal and geraniol for annotations that may be worthy of credit

DO NOT ALLOW *isomerism at C=C at carbon 6(,-7)*

ALLOW *identification of carbon-2(,3) from correct Z geraniol isomer if not stated in text or diagram*

IGNORE *cis* ***OR*** *trans isomerism (none of the substituent groups attached to the C=C are the same)*

IGNORE geometric

ALLOW *type of isomerism from E/Z labels, even if incorrectly assigned*

In geraniol,

ALLOW C_6H_{11} ***OR*** *R to represent alkenyl chain*

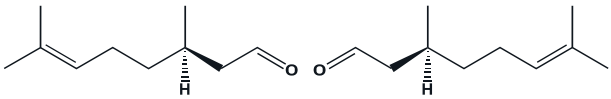
ALLOW CH_3O *to represent* CH_2OH

ALLOW *identification of carbon-3 from 3D structure citronellal if not stated in text or diagram*

optical isomerism ✓

Two 3D structures of citronellal that are mirror images ✓

e.g.



[4 marks]

IGNORE *connectivity of groups around chiral C*

In citronellal,

ALLOW C_6H_{11} ***OR*** *R to represent alkenyl chain*

ALLOW C_2H_3O *to represent* CH_2CHO

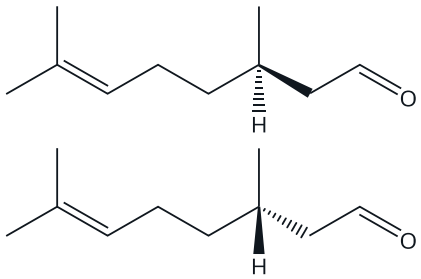
IF *structural formula of alkenyl chain is used*

IGNORE one *small slip in one/both isomers*

e.g.$(CH_3)_2CHCH_2CH_2$ (missing carbon-7)

ALLOW *two 3D structures with 2 groups swapped*

e.g.



Q125 · Basic concepts of organic chemistry · [10 marks]

OCR MARK SCHEME

20(a)(i)

Movement of an electron pair ✓

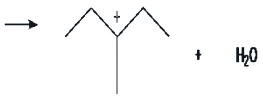
[1 mark]

EXAMINER GUIDANCE

For electron pair,

ALLOW *lone pair* ***OR*** *bonding pair* ***OR*** *2 electrons*

20(a)(ii)



Correct carbon skeleton ✓

'+' charge on correct carbon skeleton ✓

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

IGNORE *any other products*

20(a)(iii)

Heterolytic

one (bonded) atom/O receives both/2 electrons ✓

Fission

Breaking of a covalent bond

OR breaking of C-O bond ✓

[2 marks]

ALLOW *2 electrons go to one (bonded) atom/O*

IGNORE *formation of ions/radicals*

For O atom,

ALLOW *species*

DO NOT ALLOW *element* ***OR*** *molecule*

'Bond breaking' is not sufficient

(no reference to covalent)

20(b)(i)

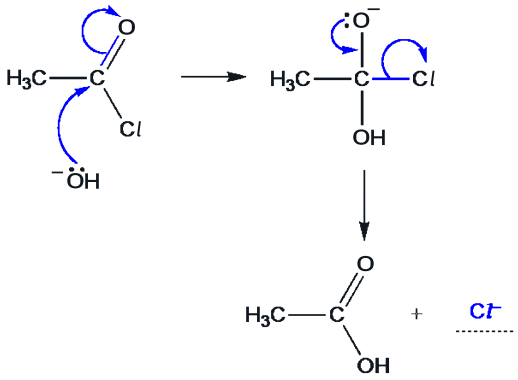
IGNORE *any dipoles shown*

NOTE*: curly arrows can be straight, snake-like, etc. but* ***NOT*** *double headed or half headed arrows*

Curly arrow from OH^- must

- go to the C of C=O

AND



✓✓✓

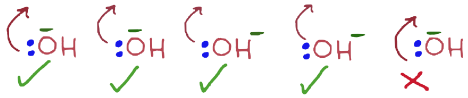
curly arrow to Cl

AND

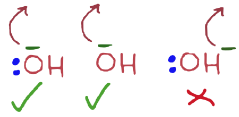
Cl^- as product ✓

[4 marks]

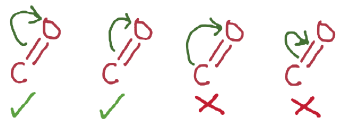
- start from, **OR** be traced back to any point across width of lone pair on O of OH^-



- **OR** start from – charge$^-$OH ion



Curly arrow from C=O bond must start from, **OR** be traced back to, any part of C=O bond and go to O

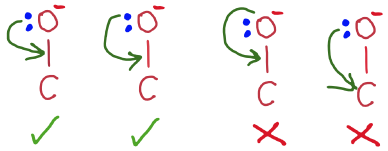


Curly arrow from O^- must

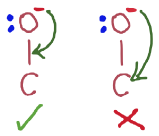
- go to C=O bond

AND

- start from, **OR** be traced back to, any point across width of lone pair



- **OR** start from '–' charge of O^-



Curly arrow from C–Cl bond must start from, **OR** be traced back to, any part of C–Cl bond and go to Cl



20(b)(ii)

(OH^-) donates an electron pair/lone pair

OR

(OH^- acts as a) nucleophile ✓

[1 mark]

Q126 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

3-Ethylhex-2-ene

Q127 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

OCR MARK SCHEME

12

EXAMINER GUIDANCE

ALLOW *12*

Q128 · Basic concepts of organic chemistry · [17 marks]

OCR MARK SCHEME

16(a)(i)

3-methylhex-2-ene ✓

[1 mark]

EXAMINER GUIDANCE

IGNORE *lack of hyphens, or addition of commas*

DO NOT ALLOW *3-methyhex-2-ene*

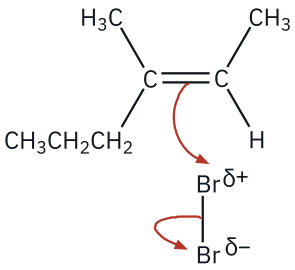
OR 3-methhex-2-ene

OR 3-methlyhex-2-ene

OR 3-methylhexan-2-ene

IGNORE *references to E/Z or cis/trans*

16(a)(ii)



Curly arrow from C=C bond to $Br^{\delta+}$ of Br–Br

AND

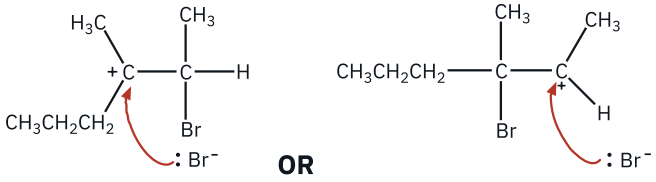
Correct dipole on Br–Br

AND

curly arrow for breaking of Br–Br bond ✓

Correct carbocation to match mechanism

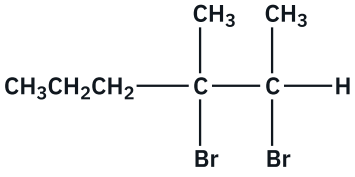
AND curly arrow from Br^- to C^+ of carbocation



✓

i.e. **ALLOW** carbonium + on either C atom

Correct product to match mechanism ✓



ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

IGNORE *connectivity of $CH_3CH_2CH_2$ and CH_3 groups in carbocation and product*

ALLOW *C_3H_7 for $CH_3CH_2CH_2$*

DO NOT ALLOW *half headed or double headed arrows but allow* ***ECF*** *if seen more than once*

DO NOT ALLOW *use of HBr but ECF for subsequent use*

For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples):

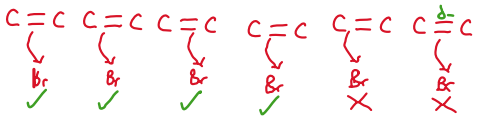
DO NOT ALLOW *partial charge on C=C*

1st curly arrow must

- go to a Br atom of Br–Br

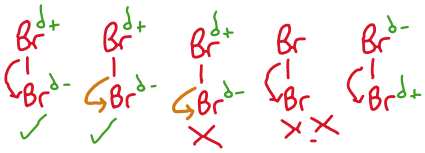
AND

start from, **OR** be traced back to any point across width of C=C



2nd curly arrow must

- start from, **OR** be traced back to, any part of $^{\delta+}Br–Br^{\delta-}$ bond
- **AND** go to Br $^{\delta-}$



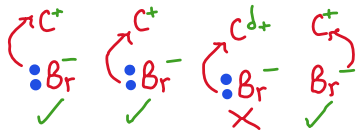
[3 marks]

3rd curly arrow must

- go to the C^+ of carbocation

AND

- start from, **OR** be traced back to any point across width of lone pair on $:Br^-$
- **OR** start from – charge on Br^- ion



(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)

ALLOW *bromonium ion*

16(b)(i)

Same molecular formula

AND

Different structural formulae ✓

OR

Both have the molecular formula C_6H_{12}

AND

Different structural formulae ✓

[1 mark]

Same formula is not sufficient

(no reference to molecular)

Different arrangement of atoms is not sufficient

(no reference to structure/structural)

For 'structural formulae',

ALLOW *structure/displayed/skeletal formulae/ functional groups*

DO NOT ALLOW *any reference to spatial/space*

16(b)(ii)

Same structural formula

AND

Different arrangement (of atoms) in space

OR different spatial arrangement (of atoms) ✓

[1 mark]

ALLOW *structure/displayed/skeletal formula*

DO NOT ALLOW *same empirical formula*

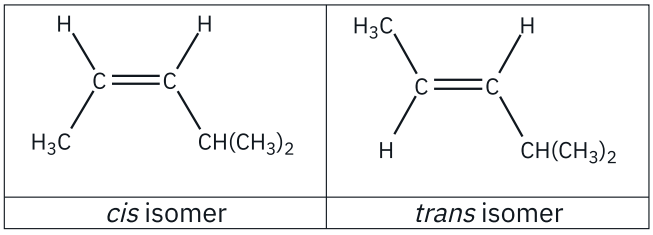
OR same general formula

IGNORE *same molecular formula*

Reference to *E*/*Z* isomerism or optical isomerism is not sufficient

16(b)(iii)

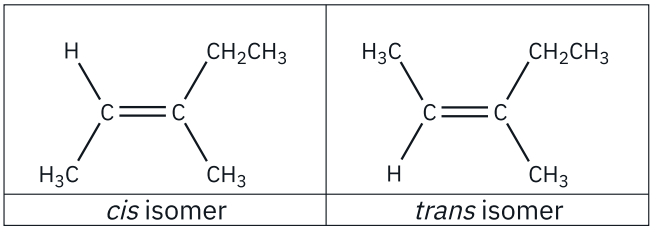
Correct identification of *cis* **AND** *trans* isomers of 4-methylpent-2-ene ✓✓



cis isomer | *trans* isomer

OR

Identification of 3-methylpent-2-ene as *cis* **AND** *trans* isomers ✓✓



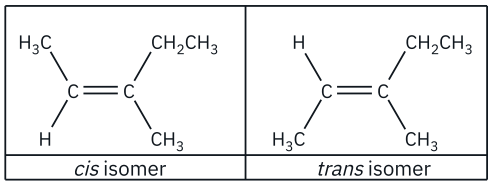
cis isomer | *trans* isomer

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

C_3H_7 is not sufficient (could be unbranched)

ALLOW *one mark if cis* ***AND*** *trans isomers of 4-methylpent-2-ene are in the wrong boxes*

ALLOW *the isomers of 3-methylpent-2-ene in either box*



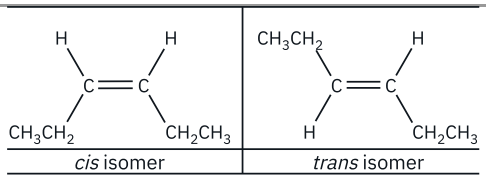
cis isomer | *trans* isomer

Ambiguity with *cis*/*trans* identification system

ALLOW *one mark for correct identification of cis* ***AND*** *trans isomers of unbranched* C_6H_{12}

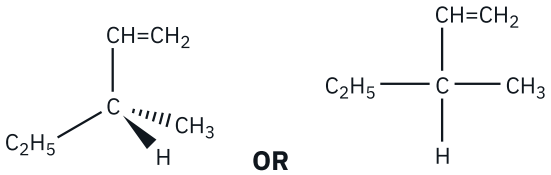
e.g.

[2 marks]



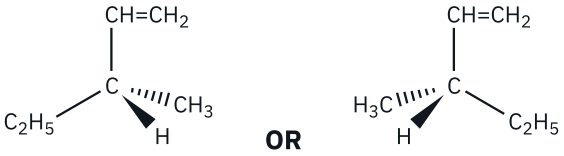
16(b)(iv)

Correct groups attached to chiral carbon of compound C seen once e.g.



✓

Two 3D structures of compound C that are mirror images with correct connectivity in both



✓

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

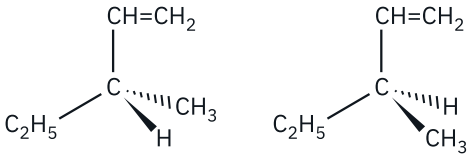
For C_2H_5–, **ALLOW** CH_3CH_2–

For –$CH=CH_2$, **ALLOW** –C_2H_3 **OR** –$CHCH_2$

For bond into paper accept:

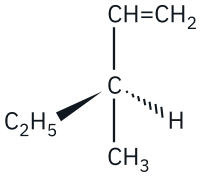


ALLOW *two 3D structures with 2 groups swapped e.g.*

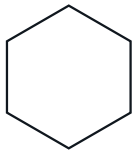
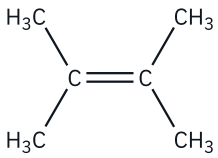


DO NOT ALLOW *a bond angle of 180°*

e.g.



16(b)(v)

	
D	**E**

ALLOW *1 mark for structures if shown in wrong boxes.*

CHECK table 16.1 for annotations that may be worthy of credit

✓ ✓

Two of the following for D ✓

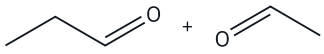
- All H are equivalent/in the same chemical environment/ the same type
- All C are equivalent/ in the same chemical environment/ the same type
- No C=C present

Two of the following for E ✓

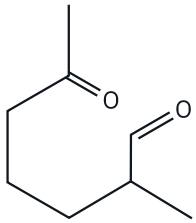
- All H are equivalent/ in the same chemical environment/ the same type
- 2 C environments
- C=C present

[4 marks]

16(c)(i)



BOTH structures required for ✓

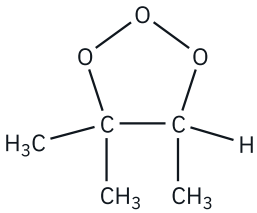


✓

> ***ALLOW*** *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

[2 marks]

16(c)(ii)



✓

> ***ALLOW*** *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

[1 mark]

Q129 · Basic concepts of organic chemistry · [1 mark]

Answer: **A**

amide and alcohol

Q130 · Basic concepts of organic chemistry · [1 mark]

Answer: **D**

Q131 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

OCR MARK SCHEME

4

EXAMINER GUIDANCE

> ***ALLOW*** *4*

Q132 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

Only 1 and 2

Q133 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

C_nH_{2n-2}

Q134 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

OCR MARK SCHEME

EXAMINER GUIDANCE

24

ALLOW *24*

Q135 · Basic concepts of organic chemistry · [1 mark]

Answer: **A**

3,5-dimethylocta-1,3,6-triene

Q136 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

3-chloro-2-methylbutan-1-ol

Q137 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

Aliphatic and alicyclic

Q138 · Basic concepts of organic chemistry · [6 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

16(a)

B, C, D AND E only ✓

[1 mark]

ALLOW *letters in any order*

16(b)

A AND B only ✓

[1 mark]

ALLOW *letters in any order*

16(c)

A AND D only ✓

[1 mark]

ALLOW *letters in any order*

16(d)

1-ethyl-2,4-dimethylbenzene ✓

[1 mark]

ALLOW *other unambiguous names using smallest numbering.*

e.g. **ALLOW** 1,3-dimethyl-4-ethylbenzene

2,4-dimethylethylbenzene

ethyl-2,4-dimethylbenzene

2,4-dimethyl-1-ethylbenzene

IGNORE *alphabetical order of methyl and ethyl*

IGNORE *lack of hyphens, extra hyphens, full stops instead of commas, extra spaces*

DO NOT ALLOW *1,5-dimethyl-2-ethylbenzene* ***OR*** *1,3-dimethyl-6-ethylbenzene*

Needs smallest numbers

DO NOT ALLOW *the following for dimethyl: dimethy, dimeth, dimethly, dimethanyl*

DO NOT ALLOW *the following for ethyl: ethy, eth, ethly, ethanyl*

16(e)

Priority groups are on the same side

(Highest) priority groups are CH_3 AND C_2H_5

OR

Low(est) priority groups CH_3 AND H

ALLOW *suitable alternatives to 'priority'*

e.g. Groups with highest atomic number or more important groups or major groups etc.

IGNORE *references to (relative) mass of groups including* A_r *or* M_r

ALLOW *suitable alternatives to 'same side'*

[2 marks]

e.g. priority groups are both on the top **OR** above the C=C

IGNORE *priority groups in same plane* ***OR*** *adjacent*

IGNORE *Use of 'molecules' instead of groups*

ALLOW *identification by name e.g. ethyl and methyl*

IF *'priority' is not mentioned* ***ALLOW*** *one mark for 'CH_3CH_2 and CH_3 are on same side'* ***OR*** *'H and CH_3 are on same side'*

Q139 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

W and Z

Q140 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

Z-3-fluoropent-2-ene

Q141 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

Q142 · Basic concepts of organic chemistry · [1 mark]

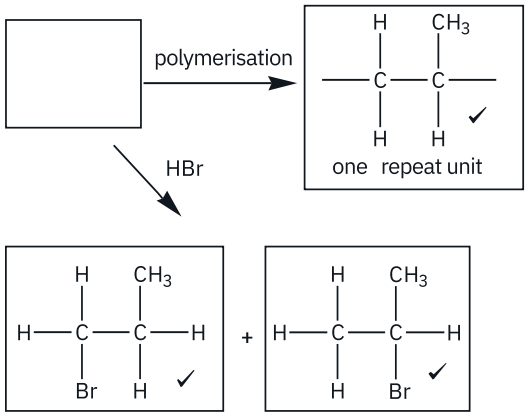
Answer: **A**

They have the same empirical formula.

Q143 · Basic concepts of organic chemistry · [15 marks]

OCR MARK SCHEME

25(a)



[3 marks]

EXAMINER GUIDANCE

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

For repeat unit,

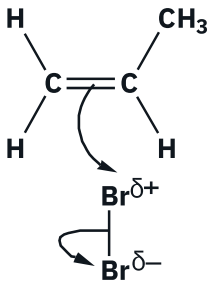
- 'side bonds' required on either side of repeat unit from C atoms
- **DO NOT ALLOW** > one repeat unit

IGNORE *brackets*

- **IGNORE** *n*

ALLOW *in either order*

25(b)



1st curly arrow

Curly arrow from double bond to Br of Br–Br ✓

DO NOT ALLOW *partial charge on C=C*

2nd curly arrow

Correct dipole on Br–Br

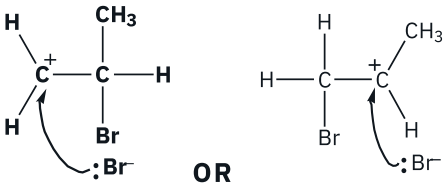
AND curly arrow for breaking of Br–Br bond ✓

3rd curly arrow

Correct carbocation with + charge on C with 3 bonds

AND curly arrow from Br^- to C^+ of carbocation

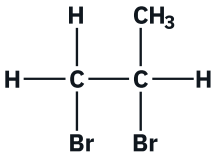
DO NOT ALLOW *δ+ on C of carbocation*



✓

i.e. **ALLOW** carbonium + on either C atom

Correct product to match mechanism ✓



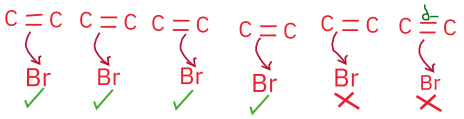
For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples)

1st curly arrow must

- go to a Br atom of Br–Br

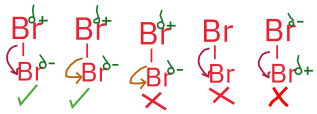
AND

- start from, **OR** be traced back to any point across width of C=C



2nd curly arrow must

- start from, **OR** be traced back to, any part of $^{\delta+}Br–Br^{\delta-}$ bond
- **AND** go to $Br^{\delta-}$

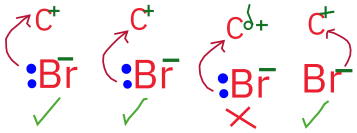


3rd curly arrow must

- go to the C^+ of carbocation

AND

- start from, **OR** be traced back to any point across width of lone pair on $:Br^-$
- **OR** start from – charge on Br^- ion



DO NOT ALLOW *half headed or double headed arrows but allow* ***ECF*** *if seen more than once*

[4 marks]

(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)

ALLOW *bromonium ion*

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

NOTE*: For a mechanism with HBr,*

ALLOW *all marks EXCEPT for final product*

25(c)(i)

(series of organic compounds with the) same functional group

OR same/similar reactions / chemical properties ✓

each successive member differs by CH_2 ✓

[2 marks]

IGNORE *reference to physical properties*

IGNORE *same general formula*

DO NOT ALLOW *same empirical* ***OR*** *molecular formula*

Differs by CH_2 is not sufficient (no successive)

ALLOW *differs by CH_2 each time AW*

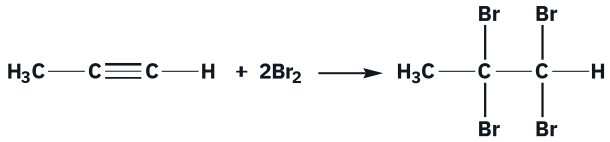
25(c)(ii)

C_nH_{2n-2} ✓

[1 mark]

ALLOW $C_nH_{2(n-1)}$

25(c)(iii)



Left-hand side, i.e. Reactants, balanced with $2Br_2$ ✓

Right-hand side, i.e. Product ✓

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

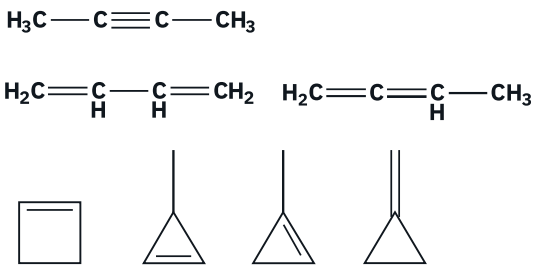
ALLOW C_3H_4 *for* $H_3CC{\equiv}CH$

Question asks only for structure of product

ALLOW $H_3CCBr_2CHBr_2$ ***OR*** $H_3CCBr_2CBr_2H$

25(c)(iv)

Any 2 structures from:

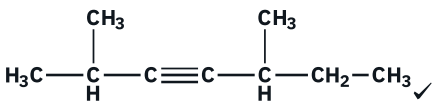


✓ ✓

[2 marks]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

25(c)(v)



[1 mark]

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Q144 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

OCR MARK SCHEME

5

EXAMINER GUIDANCE

ALLOW 5

Q145 · Basic concepts of organic chemistry · [1 mark]

Answer: **A**

$C_{18}H_{24}O_2$

Q146 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

Movement of a pair of electrons.

Q147 · Basic concepts of organic chemistry · [1 mark]

Answer: **B**

4-methylhex-1-en-3-ol

Q148 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

C_nH_{2n-2}

Q149 · Basic concepts of organic chemistry · [1 mark]

Answer: **C**

OCR MARK SCHEME

4

EXAMINER GUIDANCE

***ALLOW** 4 (This is the number of structural isomers)*

Q150 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

Step 1: electrophilic addition · Step 2: nucleophilic substitution

Q151 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

7

Level 3 (5–6 marks)

A comprehensive description with all three scientific points explained thoroughly. C identified as a carboxylic acid containing four carbon atoms linked to the peak in the mass spectrum at 43.

The explanation makes use of all the evidence including the secondary carbocation in justifying the correct structure of C.

Level 2 (3–4 marks)

Attempts all three scientific points but explanations may be incomplete.

OR Explains two scientific points thoroughly with few omissions.

The analysis is clear and includes some interpretation of IR and MS peaks.

Level 1 (1–2 marks)

A simple explanation based on at least two of the main scientific points.

OR

Explains one scientific point thoroughly with few errors.

EXAMINER GUIDANCE

LOOK ON THE SPECTRA for labelled peaks.

Indicative scientific points may include:

1. Molecular formula

Element	% mass	Ar	moles	ratio
C	54.5	12	4.54	2
H	9.1	1	9.1	4
O	36.4	16	2.28	1

- empirical formula = C_2H_4O
- molecular ion peak m/z or M_r = 88
- molecular formula = $C_4H_8O_2$

2. Infrared spectrum

The analysis is communicated in an unstructured way and includes interpretation of peaks from IR **OR** MS spectrum

0 marks – No response worthy of credit.

[6 marks]

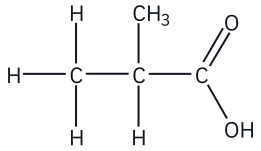
- peak at 2500–3500 (cm^{-1}) is O–H
- peak at 1630-1820 (cm^{-1}) is C=O
- C is a carboxylic acid

ALLOW stated values within the ranges above

***IGNORE** references to C–O peaks*

3. Identifying the carboxylic acid

- ($CH_3CH_2CH_2COOH$ **OR** $(CH_3)_2CHCOOH$)
- Mass spectrum peak at $m/z = 43 = C_3H_7^{(+)}$
- secondary carbocation: $CH_3C^+HCH_3$
- compound C: $(CH_3)_2CHCOOH$



***IGNORE** name of carboxylic acid if structure given*

Q152 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

Q153 · Organic synthesis, IR and mass spectra · [1 mark]

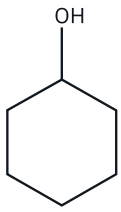
Answer: **A**

$CH_3CH_2CH(OH)CH_3$

Q154 · Organic synthesis, IR and mass spectra · [9 marks]

OCR MARK SCHEME

6(a)(i)



✓

Acid (catalyst) **AND** heat ✓

[2 marks]

EXAMINER GUIDANCE

***ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous*

***ALLOW** (heat under) reflux*

***ALLOW** H_3PO_4 **OR** H_2SO_4 **OR** H^+*

***DO NOT ALLOW** other named acids*

***IGNORE** concentration/pressure*

***IGNORE** water/steam*

6(a)(ii)

FIRST CHECK THE ANSWER ON THE ANSWER LINE

***IF** answer = 44.4(%) award all 3 marks for calculation*

Amount cyclohexene ($\frac{m}{M}$)

= $\frac{1.23}{82}$ **OR** 0.0150 mol ✓

Amount of bromocyclohexane ($\frac{m}{M}$)

= $\frac{5.50}{162.9}$ **OR** 0.0338 mol ✓

If there is an alternative answer, check to see if there is any ECF credit possible

***ALLOW 3 SF**: 0.0338 up to calculator value of 0.033763044 correctly rounded*

Common ECFs (2 marks)

- Incorrect M_r → incorrect moles of cyclohexene
- Incorrect M_r → incorrect moles of 2-bromocyclohexane

% yield

$= \frac{0.0150}{0.0338} \times 100 = 44.4(\%)$ ✓

Final answer must be to 3 significant figures

[3 marks]

e.g. **ALLOW two marks** for use of incorrect mass of bromocyclohexane with other calculations correct

e.g. $\frac{5.50}{163} = 0.033742331 \rightarrow 44.5\%$

ALLOW *calculation in mass*

Theoretical mass yield:

$m(C_6H_{10}) = 0.0338 \times 82 = 2.77$ g

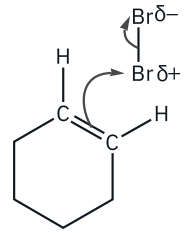
$\%\text{ yield} = \frac{1.23}{2.77} \times 100 = 44.4\%$

6(b)

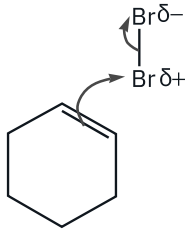
Curly arrow from double bond to Br of Br–Br ✓

Correct dipole shown on Br–Br

AND curly arrow showing breaking of Br–Br bond ✓

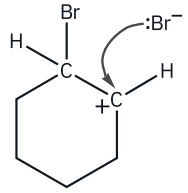


OR

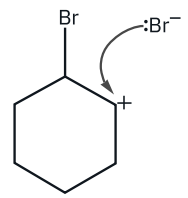


Correct carbocation with + charge on C with 3 bonds

AND curly arrow from Br^- to C^+ of carbocation ✓



OR



Correct product:

Curly arrow must start from bond and go to correct atom

DO NOT ALLOW *any other partial charges*

e.g. shown on double bond

DO NOT ALLOW *missing H on displayed formulae (penalise once only)*

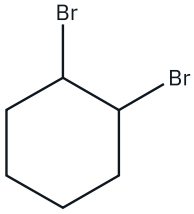
DO NOT ALLOW *δ+ on C of carbocation.*

Curly arrow must come from a lone pair on Br^-

OR from the negative sign of Br^- ion (then lone pair on Br^- ion does not need to be shown)

IGNORE *wording if diagrams are correct*

Maximum of two marks for mechanism based on incorrect structure of cyclohexene



✓

[4 marks]

Q155 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

21

Level 3 (5–6 marks)

Structure of L is $CH_3CH_2COOCH_2C(CH_3)_3$

OR $(CH_3)_3CCH_2COOCH_2CH_3$

AND

A comprehensive explanation with most of the spectral data analysed and few omissions.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Splitting patterns used to deduce the correct structure of L.

Level 2 (3–4 marks)

Attempts all three scientific points but explanations may be incomplete and/or structure of L incorrect.

OR

Explains two scientific points thoroughly with few omissions.

There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.

The analysis is clear and includes some interpretation of NMR/IR peaks.

Level 1 (1–2 marks)

A simple explanation based on at least two of the main scientific points.

OR

Explains one scientific point thoroughly with few omissions.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

The analysis is communicated in an unstructured way and includes interpretation of a few peaks from the NMR/IR spectra.

0 marks

No response or no response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

Indicative scientific points may include:

1. ^1H NMR spectrum

- δ = 1.1 ppm, triplet, 3H $CH_3–CH_2–$
- δ = 1.3 ppm, singlet, 9H $(CH_3)_3C–$
- δ = 2.3 ppm, quartet, 2H $CH_3–CH_2–C=O$
- δ = 4.0 ppm, singlet, 2H $–CH_2–O–$

ALLOW *approximate values for chemical shifts.*

2. Infrared spectra

IR spectrum of M

- peak at 2300–3700 (cm^{-1}) is O–H
- peak at ~1720 (cm^{-1}) is C=O
- M is a carboxylic acid

IR spectrum of N

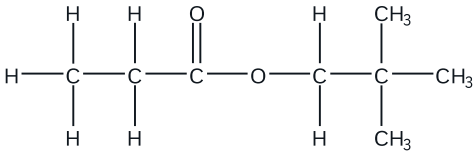
- peak at 3100-3700 (cm^{-1}) is O–H
- N is an alcohol

ALLOW *ranges from Data Sheet*

IGNORE *references to C–O peaks*

3. Structure of L

- L is an ester (as it reacts with HCl(aq) to form carboxylic acid and alcohol)
- Correct structure



ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Q156 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

$(CH_3)_2CHCH_2OH$

Q157 · Organic synthesis, IR and mass spectra · [10 marks]

OCR MARK SCHEME

5(a)(i)

Level 3 (5–6 marks)

Correctly labelled diagram of reflux apparatus that works, with no safety problems

AND

An appreciation of most of the purification steps required to gain a pure sample

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Labelled diagram of apparatus (either reflux or distillation) but with safety/procedural problems **OR** clear diagram of reflux apparatus without labelling

AND

Some details of further purification steps

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Diagram of apparatus (reflux **OR** separation **OR** distillation) drawn with no labelling **OR** labelled diagram with significant safety/procedural

AND / **OR**

Few or imprecise details about further purification stages

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

Indicative scientific points may include:

Apparatus set up for reflux:

- round-bottom/pear shaped flask
- heat source
- condenser

Detail: water flow in condenser bottom to top; open system.

Purification

- Use of a separating funnel to separate organic and aqueous layers

Detail: Collect lower organic layer density greater

- Drying with an anhydrous salt,

Detail: e.g. $MgSO_4$, $CaCl_2$, etc.

- Redistillation

Detail: Collect fraction distilling at 102°C.

5(a)(ii)

FIRST, CHECK THE ANSWER ON ANSWER LINE

***IF** answer = 12.6 (g) award 2 marks*

- n(1-bromobutane) = $0.150 \times \frac{61.4}{100} = 0.0921$ (mol) ✓
- Mass 1-bromobutane = 0.0921 × 136.9 = 12.6 (g) ✓

3 SF required

[2 marks]

Common errors:

33.4 ($0.150 \times \frac{100}{61.4} = 0.244 \times 136.9$)

1 mark

***ALLOW ECF** for incorrect moles or incorrect M_r of 1-bromobutane (provided answer is to 3 SF)*

***DO NOT ALLOW** 6.82 (using M_r of butan-1-ol)*

***ALLOW** calculation using masses, e.g.*

- Theoretical = 0.150 × 136.9 = 20.535 (g) ✓

(**ALLOW** 20.535 rounded back to 20.5)

- Actual mass = $20.535 \times \frac{61.4}{100} = 12.6$ (g) ✓

(20.5 also gives 12.6)

5(b)

Tangent on graph

drawn at approximately t = 30 min (±10 mins) ✓

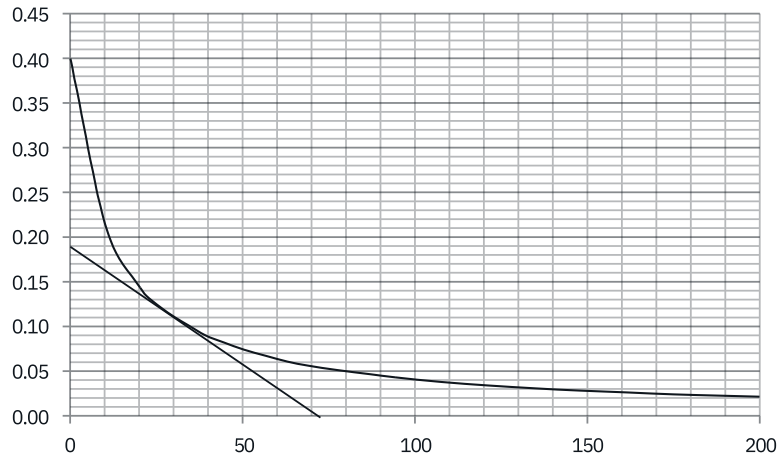
Calculation of rate

***DO NOT ALLOW** interpolation (taking a direct reading from graph), answer must be derived from taking a gradient*

***ALLOW** ecf from incorrectly drawn tangent*

= Gradient (y/x) of tangent drawn

e.g. $\frac{0.19}{72}$ = 2.64×10^{-3} / 0.00264 (mol $dm^{-3}min^{-1}$) ✓



[2 marks]

Tolerance:

Readings from y axis should be ± 0.01 mol dm^{-3} (i.e. within 1 square)

Readings from x axis should be ± 5 minutes (i.e. within 0.5 of a square)

IGNORE *units*

IGNORE *sign*

Q158 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

7

Level 3 (5-6 marks)

A comprehensive description including most of the evidence to justify the correct structure of F (accept cis or trans).

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

The candidate attempts all three scientific points, but explanations are incomplete.

OR

Explains two scientific points thoroughly with few omissions.

AND

an attempt at a feasible structure based on deduction from correct molecular formula

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

The correct empirical formula

AND a simple description based on at least one of the main scientific points.

OR

The candidate explains one scientific point thoroughly with few omissions.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

LOOK AT THE SPECTRA for labelled peaks

Indicative scientific points may include:

Empirical formula

- empirical formula = C_4H_6O

element	% mass	Ar	moles	ratio
C	68.6	12	5.72	4
H	8.6	1	8.60	6
O	22.8	16	1.43	1

IR and spectra and molecular formula

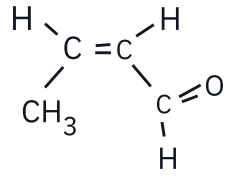
- infrared absorption; 1630–1820 cm^{-1}, due to C=O (aldehyde/ketone/carbonyl group)
- molar mass = 70 g mol^{-1}

(mass spectrum molecular ion peak m/z = 70)

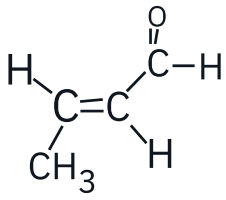
- molecular formula = C_4H_6O

Functional groups, structure and stereochemistry

- alkene / C=C
- aldehyde / –CHO ($C_3H_5^+$ fragment)
- mass spectrum; peak at 41 due to $C_3H_5^+$ (loss of CHO)
- *E*/*Z* or *cis-trans* isomer: *E*/*Z* or *cis-trans* isomer:



cis



trans (correct structure)

Q159 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **C**

$(CH_3)_2CH^+$

Q160 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

$CH_3CHOHCN$

Q161 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **A**

Q162 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

The action of IR radiation on CFCs in the upper atmosphere leads to the formation of chlorine radicals.

Q163 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

Q164 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

21

Level 3 (5–6 marks)

Structure is $CH_3C_6H_4CH(CH_3)COOH$

AND

Most of the data analysed.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

A viable aromatic structure of $C_{10}H_{12}O_2$ that contains C=O **AND** most key features consistent with spectral data

AND

Some of the spectral data analysed

EXAMINER GUIDANCE

Indicative scientific points:

Empirical and Molecular Formulae

- C : H : O = $\frac{73.17}{12.0} : \frac{7.32}{1.0} : \frac{19.51}{16.0}$

= 6.10 : 7.32 : 1.22

= 5 : 6 : 1

- Empirical formula = C_5H_6O
- uses m/z = 164.0 to determine molecular formula as $C_{10}H_{12}O_2$

Structure

***ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous*

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Correct determination of empirical formula and/or molecular formula.

OR

Analyses some of the IR and NMR data.

OR

Analyses most of the NMR data.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

Key features of an aromatic structure consistent with spectral data

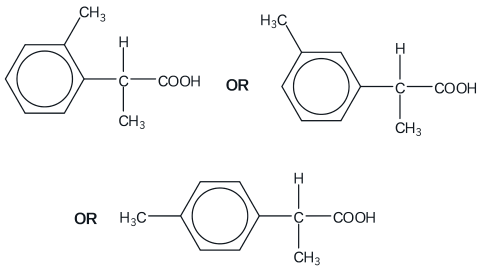
- COOH group
- 4 aromatic H atoms
- single H atom that would give a quartet
- CH_3 group that would give a doublet
- CH_3 group that would give a singlet

Correct Structure

- $CH_3C_6H_4CH(CH_3)COOH$

ALLOW *2-, 3-* ***OR*** *4- substitution of ring*

i.e.



Spectral analysis

^1H NMR

- δ = 1.6 ppm, doublet, 3H CH_3–CH–
- δ = 2.3 ppm, singlet, 3H Ar-CH_3
- δ = 2.7 ppm, quartet, 1H CO–CH–CH_3

OR Ar–CH–CH_3 / C_6H_5–CH–CH_3

- δ = 7.1–7.5 ppm, multiplet, 4H C_6H_4–

ALLOW *approximate values for chemical shifts.*

IR:

- peak at 2300–3700 (cm^{-1}) is O–H
- peak at ~1720 (cm^{-1}) is C=O
- unknown is a carboxylic acid

ALLOW *ranges from Data Sheet*

IGNORE *references to C–O peaks*

Q165 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **A**

$CH_3COCH_2CH_3$

Q166 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **C**

Q167 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

6

Level 3 (5-6 marks)

EXAMINER GUIDANCE

LOOK AT THE SPECTRA for labelled peaks

Indicative scientific points may include:

A comprehensive description including most of the evidence to justify the correct structure of A (accept *cis* or *trans*).

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Explains two scientific points thoroughly with few omissions.

AND

an attempt at a feasible structure with either a C=C **OR** COOH

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

The correct empirical formula

AND a simple description based on at least one of the main scientific points.

OR

Some aspects from two scientific points are given

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

Empirical formula

- empirical formula = C_2H_3O

element	%mass	A_r	moles	ratio
C	55.8	12	4.65	2
H	7.0	1	7.0	3
O	37.2	16	2.325	1

Spectra and molecular formula

Mass spectrum

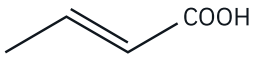
- (molecular ion peak $m/z = 86$)
- molar mass = 86 g mol^{-1}
- molecular formula = $C_4H_6O_2$

Infrared absorption;

- broad peak at 2500–3300 cm^{-1}, due to O–H in carboxylic acid,
- peak at 1630–1820 cm^{-1} due to C=O
- (peak at 1620–1680 cm^{-1} due to C=C)

Functional groups, structure and stereochemistry

- alkene / C=C
- carboxylic acid / –COOH
- mass spectrum; peak at 41 due to loss of COOH
- Correct structural formula: $CH_3CH=CHCOOH$ i.e. *cis* **OR** trans
- *trans* isomer indicates C=C bond with 2 different groups attached to both double bonded carbons
- *trans*: common groups on opposite sides of double bond
- Correct structure:



***NOTE**: Correct trans assignment with justification would be an example of a well-developed line of reasoning that is substantiated.*

Q168 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

$CH_3COOCH_2CH_3$

Q169 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

Q170 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **C**

$CH_3CH_2COCH_3$

Q171 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

$m/z = 45$

Q172 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

Q173 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **C**

Q174 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

19

Level 3 (5–6 marks)

A three stage synthesis in the correct order

AND

Equations for each stage are mostly correct

AND

Most reagents correct

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Synthesis includes at least two stages in any order **OR** uses NH_3 and HBr in the correct order (without chain extension)

AND

some of the reagents and some equations correct

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Planned synthesis includes reagents for any two stages

OR

Describes one stage with reagents and equation mostly correct

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

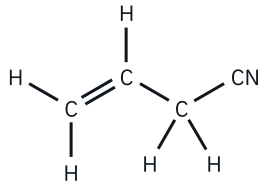
Indicative scientific points may include:

***IGNORE** conditions*

Stage 1: Reaction with CN^-

- Reagents: CN^- (in ethanol)
- Equation: $H_2C{=}CHCH_2Br + CN^- \rightarrow H_2C{=}CHCH_2CN + Br^-$

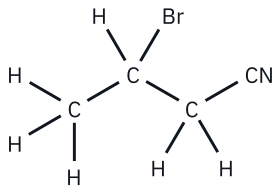
Intermediate 1



Stage 2: Addition of HBr to C=C

- Reagents: HBr
- Equation: $H_2C{=}CHCH_2CN + HBr \rightarrow CH_3CHBrCH_2CN$

Intermediate 2



Stage 3: Reduction of CN

- Reagents: H_2 (with Ni)
- Equation: $H_3CCHBrCH_2CN + 2H_2 \rightarrow CH_3CHBrCH_2CH_2NH_2$

Needs CN^- before HBr

– CN^- would react with both Br atoms

Needs HBr before H_2

– H_2 would react with C=C

Alternative three stage syntheses:

Alternative using $LiAlH_4$

Caution - Can be done as stage 2 or 3

- Reagents: $LiAlH_4$
- Equation: $H_2C{=}CHCH_2CN + 4[H] \rightarrow H_2C{=}CHCH_2CH_2NH_2$

OR

$H_3CCHBrCH_2CN + 4[H] \rightarrow CH_3CHBrCH_2CH_2NH_2$

Needs CN^- before HBr and $LiAlH_4$

Can have HBr and $LiAlH_4$ in any order

Alternative using radical substitution:

Stage 1: Reaction with CN^-

- Reagents: CN^- (in ethanol)
- Equation: $H_2C{=}CHCH_2Br + CN^- \rightarrow H_2C{=}CHCH_2CN + Br^-$

Stage 2: Reduction of CN and C=C

- Reagents: H_2 (with Ni)
- Equation: $H_2C{=}CHCH_2CN + 3H_2 \rightarrow CH_3CH_2CH_2CH_2NH_2$

Stage 3: Reaction with Br_2

- Reagents: Br_2 (with UV)
- Equation: $CH_3CH_2CH_2CH_2NH_2 + Br_2 \rightarrow CH_3CHBrCH_2CH_2NH_2 + HBr$

Needs CN^- before H_2

Needs H_2 before Br_2

Two stage synthesis using NH_3 and HBr forming product with no lengthening of carbon chain

Stage 1: Reaction of NH_3

- Reagents: NH_3 (in ethanol)
- Equation: $H_2C{=}CHCH_2Br + NH_3 \rightarrow H_2C{=}CHCH_2NH_2 + HBr$

OR $2NH_3 \rightarrow NH_4Br$

Stage 2: Addition of HBr to C=C

- Reagents: HBr
- Equation: $H_2C{=}CHCH_2NH_2 + HBr \rightarrow CH_3CHBrCH_2NH_2$

Needs NH_3 before HBr

– HBr would react with C=C

Q175 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

Carboxylic acid and ketone.

Q176 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

6

Level 3 (5–6 marks)

A comprehensive description including most of the evidence to justify the correct structure of X.

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated

Level 2 (3–4 marks)

Explains two scientific points with few omissions **OR** some aspects from all three

AND

an attempt at a feasible structure with either a C=O **OR** COOH

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Determines the correct empirical/molecular formula

OR

Some aspects from two scientific points are given

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant

0 marks – No response worthy of credit.

[6 marks]

EXAMINER GUIDANCE

LOOK ON THE SPECTRA for labelled peaks.

Indicative scientific points may include:

1. Empirical formula

Element	%mass	Ar	moles	ratio
C	40.91	12	3.41	3
H	4.54	1	4.54	4
O	54.55	16	3.41	3

Empirical formula = $C_3H_4O_3$

ALLOW *Alternative method using M_r of 88 i.e.*

$$C = \frac{88 \times (40.91/100)}{12} = 3 \text{ etc.}$$

2. Spectra and Molecular formula

Mass spectrum

- molecular ion peak m/z or $M_r = 88$
- molecular formula = $C_3H_4O_3$

IR

- peak at 2500 to 3500 cm^{-1} is O–H
- peak at 1630 to1820 cm^{-1} is C=O

3. Functional groups and structure of X

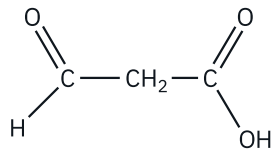
- X contains a carboxylic acid
- X doesn't decolourise Br_2 so no C=C bond
- Mass spectrum fragment peak(s) identified e.g.

- $m/z = 43$ for CH_3CO^+

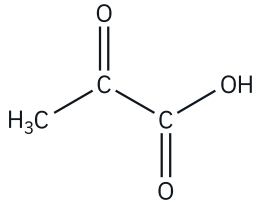
- $m/z = 29$ CHO^+

- m/z =15 due to CH_3^+

- Structure of X



OR



Aspects of the communication statement might typically have been met when evidence is presented in a logical and clear order making good use of all the evidence given.

Some points which may be seen where communication is good include:

- Easy to follow layout on empirical formula calculation
- Empirical formula is same as molecular formula i.e. not given as $CH_{1.33}O$
- IR peaks linked clearly to bond it refers to not just functional groups
- Positive charge given on MS fragments
- MS fragments plausible for the molecular formula determined.
- No additional irrelevant/incorrect information given

Q177 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

$(CH_3)_2C(OH)COOH$

Q178 · Organic synthesis, IR and mass spectra · [12 marks]

OCR MARK SCHEME

23(a)

Idea that reflux is used to prevent loss by evaporation ✓

e.g. prevents reaction mixture boiling dry

e.g. prevents loss of (volatile) compounds / products / reactants

e.g. prevent methanol escaping

[1 mark]

EXAMINER GUIDANCE

IGNORE responses related to rate of reaction

IGNORE responses related to ensuring complete reaction

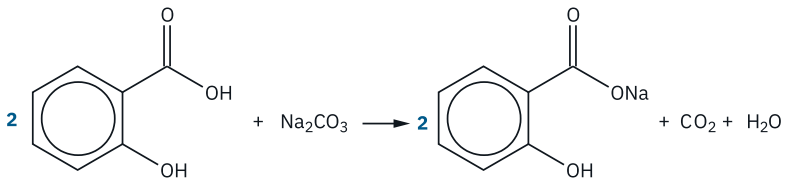
***DO NOT ALLOW** reference to incorrect reaction e.g. oxidation, combustion (flammability)*

23(b)(i)

Reaction with H_2SO_4

$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$ ✓

Reaction with excess G



Correct organic product structure ✓

Correct balanced equation ✓

ALLOW multiples in both equations

IGNORE state symbols

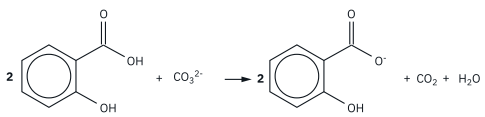
ALLOW $Na_2CO_3 + 2H_2SO_4 \rightarrow 2NaHSO_4 + CO_2 + H_2O$

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

ALLOW H_2CO_3 instead of $CO_2 + H_2O$

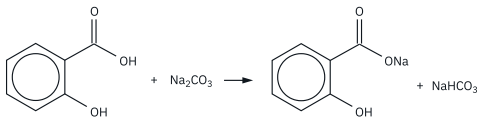
ALLOW $-COO^-$ (Na^+) for product structure mark

ALLOW ionic equation



[3 marks]

ALLOW



ALLOW H_2CO_3 instead of $CO_2 + H_2O$

ALLOW correct Kekulé representation of benzene

23(b)(ii)

(NaOH) reacts with phenol / -OH (in compound G / H)

OR (NaOH) would hydrolyse the ester / compound H

[1 mark]

IGNORE comment about whether it improves or not

DO NOT ALLOW *(NaOH) reacts with alcohol*

23(c)

FIRST CHECK ANSWER ON ANSWER LINE

If answer = 53.8 (%) award 3 marks

Theoretical moles

n(H) OR *n*(G)

$\frac{8.97}{138.0}$ OR 0.065(0) (mol) ✓

Actual moles

n(methyl salicylate) = $\frac{5.32}{152.0}$ OR 0.035(0) (mol) ✓

% yield = $\frac{0.035}{0.065} \times 100$ = 53.8% to 3 SF ✓

[3 marks]

ALLOW ECF *for each step*

TAKE CARE as value written down may be truncated but with value stored in calculator, depending on rounding, either can be credited.

IGNORE trailing zeroes e.g. 0.065 for 0.0650

DO NOT ALLOW ECF *for final mark if value is ≥100%*

DO NOT ALLOW *59.3%* ***IF*** *no moles have been calculated for final mark*

e.g. masses used $\frac{5.32}{8.97}$ x 100 = 59.3%

Calculator = 53.84615385 BUT 3 SF required for % yield

Alternative method using mass

1. Theoretical moles = 0.065(0) mol ✓

2. Theoretical mass = 0.065 × 152.0 OR 9.88 g ✓

3. % yield = $\frac{5.32}{9.88} \times 100$ = 53.8% ✓

23(d)

Steps must be given in correct order:

Step 1

(Add to) separating funnel ✓

(Use of) bottom layer (containing H / organic) ✓

Step 2

Dry with an anhydrous salt

OR

Dry with $MgSO_4$ /magnesium sulfate OR $CaCl_2$ /calcium chloride ✓

Step 3

(Re)Distil at 222 °C ✓

[4 marks]

Mark each step in order but then don't mark any further if response refers to purification of a solid

e.g. dissolve in minimum amount of hot solvent, evaporate off water to allow solid to crystalise

IGNORE use of carbonate (to remove excess acid) OR (saturated) NaCl

ALLOW (remove) aqueous layer on the top

ALLOW description that aqueous layer can be determined by adding water and seeing which layer increases in size

IGNORE distillation OR filtration prior to step 1 OR step 2

ALLOW 'to remove water' instead of 'dry'

IGNORE any other named salt, e.g. 'an anhydrous salt e.g. $CaCO_3$' is acceptable

IGNORE filtration to remove anhydrous salt after step 2

ALLOW termperature range of 220-224°C for distillation

DO NOT ALLOW *if forms a solid product*

Q179 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **A**

Infrared radiation causes bonds in CH_4 molecules to vibrate more.

Q180 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

$H_3CCH{=}CHCH_2CH_3$

Q181 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

CH_3CH_2CHO

Q182 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

6(a)(i)

P : CH_3CO^+ ✓

Q : $CH_3COCH_2CH_3^+$ ✓

[2 marks]

EXAMINER GUIDANCE

ALLOW *correct structural* ***OR*** *skeletal* ***OR*** *displayed formula* ***OR*** *mixture of the above for both structures*

+ charge (anywhere on structure) required for each response

ALLOW *one mark if both formulae are correct but with no charge/incorrect charge*

ALLOW *one mark if both formulae are correct but incorrectly labelled P/Q*

6(a)(ii)

(M+1 peak due to small proportion of) Carbon-13 / C-13

[1 mark]

6(b)(i)

(causes bonds to) vibrate more (and absorb energy) ✓

[1 mark]

DO NOT ALLOW *Bond breaking*

6(b)(ii)

Functional Group

Alcohol

OR

Alkene ✓

Name of functional group required not just bond

Explanation

O–H **AND** broad peak at 3200 - 3600 cm^{-1}

OR

C=C **AND** sharp peak at 1620 -1680 cm^{-1} ✓

Explanation must contain bond and either an appropriate range or value given within range stated.

[2 marks]

Marks can be awarded from anywhere in response – does not need to be on the correct line.

IGNORE *Alkane*

DO NOT ALLOW *any other functional group*

IGNORE *'hydroxyl' for 'alcohol'*

If no or incomplete explanation, check spectrum for annotations – credit can be given from correctly labelled peaks.

ALLOW *'OH' or 'hydroxyl' for 'O-H'*

IGNORE *all other bonds, except O-H and C=C, even if incorrect*

Q183 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **A**

Catalytic ozone depletion

Q184 · Organic synthesis, IR and mass spectra · [6 marks]

OCR MARK SCHEME

17

Level 3 (5–6 marks)

Correct calculation of mass of D required

AND

Gives correct reagents for both stages of the synthesis in the correct order with both equations mostly correct

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

EXAMINER GUIDANCE

Indicative scientific points may include:

Calculation of mass of D

Using moles:

- $n(\text{F}) = \dfrac{2.50}{102} = 0.0245\ldots$ (mol)
- $n(\text{D}) = \dfrac{0.0245\ldots \times 100}{31.5} = 0.0778\ldots$ (mol)
- $m(\text{D}) = 0.0778\ldots \times 122.5 = 9.53$ (g)

Using mass:

Correct calculation of mass of D required

AND

Gives correct reagents for one stage of the synthesis with equation mostly correct

OR

Calculation of mass of D is partly correct

AND

Gives correct reagents for both stages of the synthesis

OR

Gives correct reagents for both stages of the synthesis, in the correct order, with equations mostly correct

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Calculation of mass of D is partly correct

OR

Gives correct reagents for both stages of the synthesis

OR

Describes one stage of the synthesis with reagents and equation mostly correct

OR

Attempts to calculate the mass of D but makes little progress

AND

Correct reagent for one stage of the synthesis

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

- Theoretical m(F) = $\frac{2.50 \times 100}{31.5}$ = 7.94 (g)
- Theoretical n(D) = $\frac{7.94}{102}$ = 0.0778... (mol)
- m(D) = 0.0778... × 122.5 = 9.53 (g)

ALLOW *small slip/rounding errors such as errors in M_r e.g. use of M_r of 101 instead of 102 for F*

Note: allow use of calculator value, or values rounded to min. 3SF

Examples of partly correct calculations:

Mass = 0.946 (g) from $\frac{0.0245... \times 31.5}{100}$ × 122.5 (inverted % yield)

Mass = 3.00 (g) from 0.0245... × 122.5 (omission of % yield)

Mass = 6.61 (g) from M_r values wrong way round

Synthesis

In equations, **ALLOW** any unambiguous formulae

IGNORE *conditions or solvents*

Stage 1 (oxidation of 2° alcohol)

Reagents: $H^+/Cr_2O_7^{2-}$

ALLOW *$K_2Cr_2O_7$* ***OR*** *$Na_2Cr_2O_7$* ***AND*** *H_2SO_4*

ALLOW *names for reagents e.g. acidified dichromate, if no formulae given*

IGNORE *Roman numerals e.g. (VI), unless incorrect*

Equation:



Stage 2 (substitution of Cl)

Reagents: NaOH **OR** KOH **OR** OH^-

ALLOW *H_2O*

Equation:



ALLOW *correct ionic equation/mechanism showing OH^- and Cl^-*



IF *stage 2 (substitution of Cl) attempted first*

Equation:



Then oxidation step follows

Equation:



Aspects of the communication statement might typically have been met when:

- All information given is correct and relevant using appropriate scientific language, for example:

○ no additional incorrect reagents e.g. NaOH and H_2SO_4 for substitution

○ use of an inappropriate acid e.g. HCl for oxidation

- Equations are correctly balanced
- Calculations are set out in a clear and logical way
- No small slips/rounding errors
- Final value for mass given to an appropriate number of significant figures/decimal places.

Q185 · Organic synthesis, IR and mass spectra · [10 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

23(a)

Functional group and reasoning for compound K

alcohol

AND

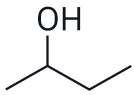
OH

AND

peak at 3200 – 3600 (cm^{-1}) ✓

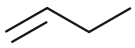
Possible structures of K, L and M

K =



✓

L =



✓

M =



✓

[4 marks]

DO NOT ALLOW *any other functional group e.g. phenol, carboxylic acid*

IGNORE *'hydroxyl' for 'alcohol'* ***BUT ALLOW*** *for O-H*

ALLOW *any stated value in range 3100 to 3600 (cm^{-1}) (consistent with spectrum provided)*

IGNORE *reference to C-O*

If no or incomplete answer, check spectrum for annotations – credit can be given from a correctly labelled peak (values are not needed)

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

ALLOW *one mark if L and M both correct but in the wrong boxes*

23(b)

Level 3 (5–6 marks)

Structure is either $CH_3CH_2COOCH(CH_3)_2$ **OR** $(CH_3)_2CHCOOCH_2CH_3$

AND

Most of the data analysed

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Structure has a molecular formula of $C_6H_{12}O_2$ with at least two key features present

AND

Analyses some of the data from the NMR

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Attempts analysis from at least 2 of the scientific points.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

Indicative scientific points:

1. Empirical Formula

- C : H : O = $\frac{62.07}{12.0} : \frac{10.34}{1.0} : \frac{27.59}{16.0}$ = 5.17 : 10.34 : 1.72 = 3 : 6 : 1
- Empirical formula = C_3H_6O
- **ALLOW** Alternative method using M_r of 116 e.g $\frac{(0.6270 \times 116)}{12} = 6$

2. Molecular Formula and Mass Spectrum

- uses *m/z* = 116.0 to determine molecular formula as $C_6H_{12}O_2$
- Any possible fragments, for example:

- m/z = 43 $(CH_3)_2CH^+$

- m/z = 29 $CH_3CH_2^+$

3. ^1H NMR analysis

- δ = 1.1 ppm, triplet, 3H CH_3CH_2–
- δ = 1.4 ppm, doublet, 6 H –$CH(CH_3)_2$
- δ = 2.4 ppm, quartet, 2H CH_3CH_2CO
- δ = 4.4 ppm, heptet, 1H –$OCH(CH_3)_2$

ALLOW *approximate values for chemical shifts.*

ALLOW *multiplet for heptet*

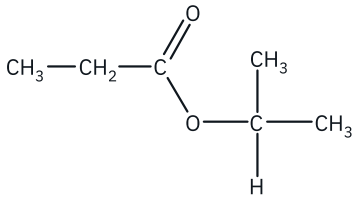
4. Structure

ALLOW *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Key Features

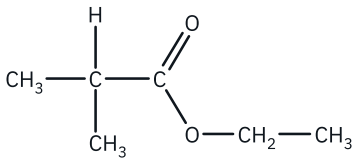
- Carbonyl -C=O
- C-O bond
- Ethyl group -CH_2CH_3
- Dimethyl group -$C(CH_3)_2$

Correct structure



Justified from NMR chemical shift analysis

OR



Justified from MS fragment as $(CH_3)_2CHCO^+$ at 71

Aspects of the communication statement being met might typically includes;

- Structures given are feasible and unambiguous
- Justifying the correct structure from the evidence
- Easy to follow layout on empirical formula calculation
- Plausible MS fragments (ideally with a positive charge shown)
- Clear information for each NMR peak, including use of correct terminology for splitting patterns
- No additional irrelevant/incorrect information given

Q186 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **C**

Q187 · Organic synthesis, IR and mass spectra · [8 marks]

OCR MARK SCHEME

EXAMINER GUIDANCE

20(a)

Level 3 (5-6 marks)

A correct calculation of the mass of cyclopentanol

AND

A detailed description of most purification steps

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3-4 marks)

Calculates the mass of cyclopentanol with some errors

AND

A detailed description of some purification steps

OR

A correct calculation of the mass of cyclopentanol

AND

A detailed description of a few purification steps

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1-2 marks)

Calculates the mass of cyclopentanol with some errors

OR

A detailed description of some purification steps

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks No response or no response worthy of credit.

[6 marks]

Indicative scientific points may include:

Calculation of mass of cyclopentanol

Using moles

- n(cyclopentene) = $\frac{4.00}{68}$ = 0.0588.... (mol)
- n(cyclopentanol) = $\frac{0.0588 \times 100}{64}$ = 0.0919...(mol)
- Mass of cyclopentanol = 86 × 0.0919 = 7.90 g

Using mass

- Theoretical mass cyclopentene= $\frac{4.00 \times 100}{64}$ = 6.25 g
- Theoretical n(cyclopentanol) = $\frac{6.25}{68}$ = 0.0919 (mol)
- Mass of cyclopentanol = 86 × 0.0919 = 7.90 g

ALLOW *for small slip in M_r / rounding errors*

Examples of some calculation errors

Incorrect inverse ratio:

- $\frac{0.0588 \times 64}{100}$ = 0.0376.... (mol)
- Mass = 86 × 0.0376 = 3.24 g

Ignoring % yield gives:

- $\frac{4.00}{68}$ = 0.0588.... (mol)
- Mass = 86 × 0.0588 = 5.06 g

Purification

- Add a neutralising agent by formula or name e.g. Na_2CO_3
- In separating funnel, organic layer is on top
- Drying with an anhydrous salt by formula or name, e.g. $MgSO_4$, Na_2SO_4, $CaCl_2$
- Redistil at approx. 44°C

Examples of detail in bold (**NOT INCLUSIVE**)

20(b)

C=C/alkene peak in region 1620-1680 cm^{-1} ✓

O–H/alcohol peak in region 3200-3600 cm^{-1} ✓

[2 marks]

LOOK ON THE SPECTRUM for labelled peaks which can be given credit

IGNORE *references to C-O at 1000cm^{-1}*

Q188 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

Absorption of IR radiation causes covalent bonds to vibrate more.

Q189 · Organic synthesis, IR and mass spectra · [5 marks]

OCR MARK SCHEME

26

Mass spectrum:

M = 88 ✓

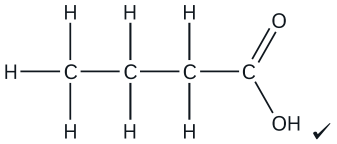
IR:

Peak at 1630-1820 (cm^{-1}) is C=O ✓

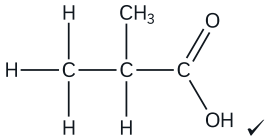
Peak at 2500–3500 (cm^{-1}) is O–H

AND carboxylic acid ✓

Structures



✓



✓

[5 marks]

EXAMINER GUIDANCE

> ***ALLOW*** *stated values within stated ranges*
>
> ***ALLOW*** *'acid O–H*
>
> ***IGNORE*** *references to C–O peaks*
>
> ***ALLOW*** *any combination of skeletal* ***OR*** *structural* ***OR*** *displayed formula as long as unambiguous*

Q190 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **D**

$CH_3COCH(OH)CH_3$

Q191 · Organic synthesis, IR and mass spectra · [1 mark]

Answer: **B**

m/z = 29

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