

Mark schemes

1

- (a) (i) C 1
- (ii) A 1
- (iii) D 1
- (iv) B 1

- (b) **M1** Br₂ **OR** bromine (water) **OR** bromine (in CCl₄ / organic solvent)
If M1, has no reagent or an incorrect reagent, CE=0
Ignore "acidified"
For M1 penalise Br (or incorrect formula of other correct reagent), but mark on
For M1, it must be a whole reagent and/or correct formulae

Either order

If oxidation state given in name, it must be correct.

- M2** cyclohexane **OR A** or the alkane: remains orange / red / yellow / brown / the same **OR** no reaction **OR** reference to colour going to cyclohexane layer

For M2 credit "no change"

Ignore "nothing"

Ignore "nothing happens"

Ignore "no observation"

- M3** cyclohexene **OR D** or the alkene: decolourised / goes colourless / loses its colour

For M3, ignore "goes clear"

Alternatives : potassium manganate(VII)

M1 KMnO₄ in acid **M2** purple **M3** colourless

M1 KMnO₄ in alkali / neutral **M2** purple **M3** brown solid

Give appropriate credit for the use of iodine and observations

No credit for combustion observations

3

(c) **M1** acidified potassium or sodium dichromate
For M1, it must be a whole reagent and/or correct formulae

OR eg $\text{H}_2\text{SO}_4 / \text{K}_2\text{Cr}_2\text{O}_7$ **OR** $\text{H}^+ / \text{K}_2\text{Cr}_2\text{O}_7$

OR correct combination of formula and name
If oxidation state given in name, it must be correct.

M2 oxidation **OR** oxidised **OR** redox
Do not penalise incorrect attempt at formula if name is correct or vice versa

M3 secondary / 2° (alcohol)
Credit acidified potassium chromate(VI) / $\text{H}_2\text{SO}_4 + \text{K}_2\text{CrO}_4$

3

(d) **M1** (free-) radical substitution (mechanism)
M1 both words required

M2 $\text{Br}_2 \longrightarrow 2\text{Br}\cdot$
Penalise absence of dot once only.

M3 $\text{Br}\cdot + \text{CH}_4 \longrightarrow \cdot\text{CH}_3 + \text{HBr}$
Penalise + or – charges every time

M4 $\text{Br}_2 + \cdot\text{CH}_3 \longrightarrow \text{CH}_3\text{Br} + \text{Br}\cdot$
Accept dot anywhere on methyl radical
Accept a correct termination step for 1 mark if neither M3 nor M4 are scored; otherwise ignore termination steps
Mark independently
NB If Cl_2 is used, penalise every time (this may be for M2, M3 and M4)
If cyclohexane is used, penalise every time (this may be for M3 and M4)

M5 Condition
ultra-violet / uv / sun light

OR high temperature

OR $125\text{ }^\circ\text{C} \leq T \leq 600\text{ }^\circ\text{C}$

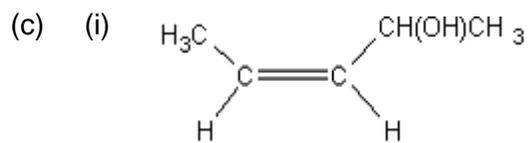
OR $400\text{ K} \leq T \leq 870\text{ K}$
For M5 ignore “heat”

5

[15]

- 2** (a) H **OR** hydrogen **OR** H[•]
Ignore brackets ignore dot
penalise + or – charge 1
- (b) CH₃ **OR** methyl **OR** CH₃[•] **OR** [•]CH₃
Ignore brackets ignore dot
penalise + or – charge 1
- (c) Either order
- C₂H₅ **OR** ethyl **OR** CH₃CH₂[•] **OR** C₂H₅[•]
Ignore brackets ignore dot
penalise + or – charge 1
- CHO **OR** HCO **OR** COH **OR** H—C=O 1
- (d) I A 1
- II C 1
- III D 1
- IV B 1
- [8]**

- 3** (a) Pentan-2-one
ONLY but ignore absence of hyphens 1
- (b) Functional group (isomerism)
Both words needed 1



Award credit provided it is obvious that the candidate is drawing the Z / cis isomer

The group needs to be CHOHCH₃ but do not penalise poor C–C bonds or absence of brackets around OH

Trigonal planar structure not essential

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(ii) Restricted rotation (about the C=C)

OR

No (free) rotation (about the C=C)

1

(d)

<p>M1 Tollens' (reagent) (Credit ammoniacal silver nitrate OR a description of making Tollens') (Do not credit Ag^+, AgNO_3 or $[\text{Ag}(\text{NH}_3)_2]^+$ or "the silver mirror test" on their own, but mark M2 and M3)</p>	<p>M1 Fehling's (solution) / Benedict's (Penalise $\text{Cu}^{2+}(\text{aq})$ or CuSO_4 but mark M2 and M3)</p>
<p>M2 <u>silver mirror</u> OR <u>black solid or black precipitate</u></p>	<p>M2 <u>Red solid/precipitate</u> (Credit <u>orange</u> or <u>brown solid</u>)</p>
<p>M3 (stays) colourless OR no (observed) change / no reaction</p>	<p>M3 (stays) blue OR no (observed) change / no reaction</p>

If **M1** is blank CE = 0, for the clip

Check the partial reagents listed and if M1 has a totally incorrect reagent, CE = 0 for the clip

Allow the following alternatives

M1 (acidified) potassium dichromate(VI) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) green

M3 (stays) orange / no (observed) change / no reaction

OR

M1 (acidified) potassium manganate(VII) (solution); mark on from incomplete formulae or incorrect oxidation state

M2 (turns) colourless

M3 (stays) purple / no (observed) change / no reaction

In all cases for **M3**

Ignore "nothing (happens)"

Ignore "no observation"

3

(e) (i) **Spectrum is for Isomer 1**

or named or correctly identified

The explanation marks in (e)(ii) depend on correctly identifying Isomer 1.

The identification should be unambiguous but candidates should not be penalised for an imperfect or incomplete name. They may say "the alcohol" or the "alkene" or the "E isomer"

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(ii) **If Isomer 1 is correctly identified, award any two from**

- (Strong / broad) absorption / peak in the range **3230 to 3550** cm^{-1} or specified value in this range or **marked correctly** on spectrum
and
(characteristic absorption / peak for) OH group / **alcohol** group
- No absorption / peak in range **1680 to 1750** cm^{-1} or absence marked correctly on spectrum
and
(No absorption / peak for a) **C=O** group / **carbonyl** group / **carbon-oxygen double bond**
- Absorption / peak in the range **1620 to 1680** cm^{-1} or specified value in this range or marked correctly on spectrum
and
(characteristic absorption / peak for) **C=C** group / **alkene** / **carbon-carbon double bond**

If 6(e)(i) is incorrect or blank, CE=0

Allow the words “dip” OR “spike” OR “trough” OR “low transmittance” as alternatives for absorption.

Ignore reference to other absorptions e.g. C-H, C-O

2

[10]

4

(a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2

Accept multiples

Ignore state symbols

Allow crossed out nitrate ions, but penalise if not crossed out

3

(ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)
Ignore reference to “false positive”

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(iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F

- M2**
- Silver fluoride / AgF is soluble / dissolves (in water)
 - no precipitate would form / no visible / observable change
*Do not penalise the spelling “fluoride”,
Penalise “fluride” once only
Mark M1 and M2 independently*

2

(b) **M1** $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$

(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 BaSO₄ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore “milky”

If BaSO₃ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT “It” unless clearly BaSO₄

4

(c) **M1** $2(12.00000) + 4(1.00794) = 28.03176$

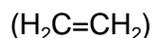
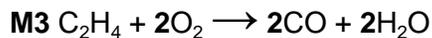
M2 Ethene and CO or “they” have an imprecise M_r of 28.0 / 28

OR

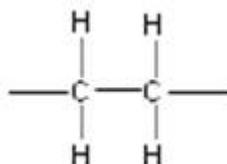
Ethene and CO or “they” have the same M_r to one d.p.

OR

These may be shown by two clear, simple sums identifying both compounds



M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p. for hydrogen

Penalise “similar” or “close to”, if this refers to the imprecise value in M2, since this does not mean “the same”

For M3, accept $CH_2=CH_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise “sticks”

*Ignore brackets around **correct** repeating unit but penalise “n”*

Penalise “additional”

5

[15]

5

Test

bromine (water) / iodine

Accept ‘Br₂’ or ‘bromine in a named solvent’.

Do not accept ‘Br’

Use of UV light, CE (lose next mark as well)

1

Observation orange / yellow / (red-)brown to colourless

Must have correct reagent to score this mark.

For I₂, allow red-brown / purple to colourless.

1

[2]

6

- (i) More absorption/less transmittance of infrared radiation
by it/water vapour

OR broader absorption by OH

OR less absorption/more transmittance of infrared radiation
by carbon dioxide

Must be comparative

This may be described and must not be contradictory

Credit answers which refer correctly to “transmittance”

(more absorption = less transmittance)

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- (ii) **M1** CO₂ contains C=O (stated like this or in words or strongly implied) OR is O=C=O

M2 depends on correct M1

OR expected absorption/peak (for C=O) is missing

OR expected absorption/peak (for C=O) is shifted to 2300 (cm⁻¹)

OR asymmetric stretching is occurring (due to C=O)

If M1 and M2 not scored, give one mark for either

No absorption/peak at 1700 (cm⁻¹)/1715 (cm⁻¹)

OR no absorption in the range 1680 – 1750 (cm⁻¹)

Ignore “carbon-oxygen bonds”, “C-O bonds”

Ignore reference to other absorptions

For M2

Allow “dip” OR “spike” OR “low transmittance” as alternatives for absorption.

2

[3]

7

(a) (i) Electron pair donor

OR

Species which uses a pair of electrons to form a co-ordinate/covalent bond.

Credit "lone pair" as alternative wording

Credit "electron pair donator"

1

(ii) Replacement of the halogen (atom) (by the nucleophile)

OR

The carbon-halogen bond/C-X breaks and a bond forms with the nucleophile or between the carbon and the nucleophile

They must describe the idea of substitution in a haloalkane.

Accept the idea that a nucleophile replaces the halogen which becomes a halide ion

Penalise reference to "halogen molecule" and penalise the idea that the haloalkane contains a halide

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(iii) Splitting molecules using/by water

OR

breaking/splitting/dissociating (C_iVX) bond(s)/using/by water

NOT simply the reaction with water or simply the addition of water.

Ignore "compound"

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(iv) (Heat) energy/enthalpy required/needed/absorbed (at constant pressure) to break/split it/the (carbon-halogen) bond

OR

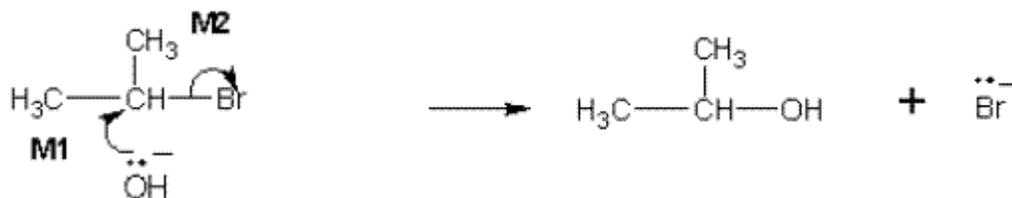
(Heat) energy/enthalpy required/needed/absorbed (at constant pressure) for homolysis of the (C-X/the carbon-halogen) bond

Ignore bond formation

Ignore "average"

1

(b)



M1 must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the central C atom.

M2 must show the movement of a pair of electrons from the C-Br bond to the Br atom. Mark M2 independently.

Award full marks for an S_N1 mechanism in which M1 is the attack of the hydroxide ion on the intermediate carbocation.

Penalise M1 if covalent KOH is used

Penalise M2 for formal charge on C or incorrect partial charges

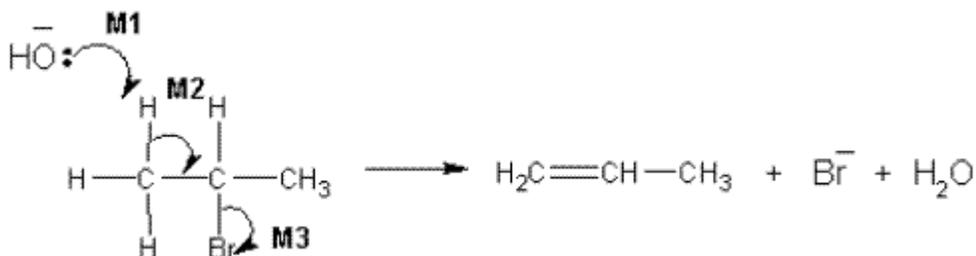
Penalise once only for a line and two dots to show a bond.

Max 1 mark for the wrong reactant

Accept the correct use of "sticks"

2

(c) (i)



M1 must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion to the correct H atom

M2 must show an arrow from the correct C-H bond to the C-C bond and should only be awarded if an attempt has been made at M1

M3 is independent provided it is from the original molecule

Award full marks for an E1 mechanism in which M2 is on the correct carbocation.

Penalise M1 if covalent KOH

Penalise M3 for formal charge on C or incorrect partial charges

Penalise once only for a line and two dots to show a bond.

Max 2 marks for wrong reactant

Accept the correct use of "sticks" for the molecule except for the C-H being attacked

3

- (ii) **M1** Stated that the spectrum has an absorption/absorbance/ peak in the range 1620 cm⁻¹ to 1680 (cm⁻¹) or specified correctly in this range from the spectrum

M2 depends on correct range or wavenumber being specified

M2 (Infrared absorption) due to C=C OR carbon-carbon double bond
QoL for correct M1 statement which includes both the word absorption (or alternative) and the correct range or wavenumber

Allow "peak" OR "dip" OR "spike" OR "trough"

OR "low transmittance" as alternatives for absorption.

For M2 it is not sufficient simply to state that an alkene has C=C

M2 could be on the spectrum

Ignore reference to other absorptions

2

[11]

8

(a) The molecular ion is

- The molecule with one/an electron knocked off/lost
Ignore the highest or biggest m/z peak

OR

- The molecule with a (single) positive charge

OR

- the ion with/it has the largest/highest/biggest m/z (value/ratio)
Ignore "the peak to the right"

OR

- the ion with/it has an m/z equal to the M_r
Ignore "compound"

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- (b) (i) $2(14.00307) + 15.99491 = 44.00105$
A sum is needed to show this

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- (ii) Propane/C₃H₈ and carbon dioxide/CO₂ (and N₂O) or they or both the gases/molecules or all three gases/molecules have an (imprecise) M_r of 44.0 (OR 44)

OR

they have the same M_r or molecular mass (to one d.p)

This could be shown in a calculation of relative masses for propane and carbon dioxide

1

- (iii) By definition

OR

The standard/reference (value/isotope)

Ignore "element"

Ignore "atom"

1

- (c) (i) **M1 (could be scored by a correct mathematical expression)**

$$\Delta H = \sum \Delta H_{\text{products}} - \sum \Delta H_{\text{reactants}}$$

OR a correct cycle of balanced equations

M1 and M2 can be scored with correct moles as follows

$$\Delta H + 2(-46) = +82 + 3(-286)$$

$$\Delta H - 92 = -776$$

$$\Delta H = 92 - 776 \text{ OR } 92 + 82 - 858$$

M3

$$\Delta H = \underline{-684} \text{ (kJ mol}^{-1}\text{) (This is worth 3 marks)}$$

Award 1 mark ONLY for + 684

Full marks for correct answer.

Ignore units.

Deduct one mark for an arithmetic error.

3

- (ii) The value is quoted at a pressure of 100 kPa OR 1 bar or 10⁵ Pa

OR

All reactants and products are in their standard states/their normal states at 100 kPa or 1 bar

Ignore 1 atmosphere/101 kPa

Ignore "constant pressure"

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[8]

9

- (a) (i) **3-bromo-3-methylpentane ONLY**

Must be correct spelling but ignore hyphens and commas

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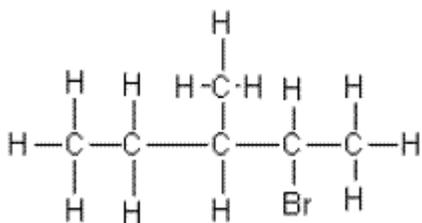
- (ii) Electrophilic addition (reaction)

Both words needed

Accept phonetic spelling

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- (iii) **M1** Displayed formula of 2-bromo-3-methylpentane

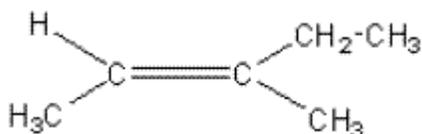


All the bonds must be drawn out but ignore bond angles

- M2** Position(al) (isomerism)
Do not forget to award this mark

2

- (iv) Structure of (E)-3-methylpent-2-ene



The arrangement of groups around the double bond must be clear with the ethyl group attached in the correct order. Ignore bond angles.

Accept C₂H₅ for ethyl

Be lenient on C – C bonds. The main issue here is whether they have drawn an (E) isomer.

Accept “sticks” for C – H bonds and correct skeletal formula

1

- (b) (i) **M1** R is represented by **Spectrum 2**

- M2** Spectrum 2 shows an infrared absorption/spike/dip/trough/peak with any value(s)/range within the range 1620 to 1680 (cm⁻¹) OR this range quoted/identified and this is due to C=C
OR this information could be a correctly labelled absorption on the spectrum

OR Spectrum 1 does not have an infrared absorption in range 1620 to 1680 (cm⁻¹) and does not contain C=C.

Award M1 if it is obvious that they are referring to the second spectrum (or the bottom one)

M2 depends on a correct M1

Ignore other correctly labelled peaks

Ignore reference to “double bond” or “alkene”

2

- (ii) Functional group (isomerism)

1

(iii) Cyclohexane

OR

Methylcyclopentane etc.

Named correctly

Ignore structures and ignore numbers on the methyl group of methylcyclopentane

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[9]