M1.(a) (i) C

1

(ii) A

1

(iii) D

1

(iv) B

1

(b) **M1** Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / 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 $KMnO_4$ in acid **M2** purple **M3** colourless

M1 $KMnO_4$ 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 H_2SO_4 / $K_2Cr_2O_7$ ***OR*** H^+/ $K_2Cr_2O_7$

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) / H_2SO_4 + K_2CrO_4

3

(d) **M1** (free-) radical substitution (mechanism)

M1 both words required

M2 $Br_2 \longrightarrow 2Br\bullet$

Penalise absence of dot once only.

M3 $Br\bullet + CH_4 \longrightarrow \bullet CH_3 + HBr$

Penalise + or – charges every time

M4 $Br_2 + \bullet CH_3 \longrightarrow CH_3Br + Br\bullet$

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 °C ≤ T ≤ 600 °C

OR 400 K ≤ T ≤ 870 K

For M5 ignore "heat"

5

[15]

M2.(a) OH acid (present in acid not in ester)

Allow absorption at 2500–3000 cm^{-1} in acid.

1

(b) C=O or (absorption at) 1680–1750 cm^{-1}
(present in acid not in alcohol)

Allow correct distinction between 3230–3550 cm^{-1} for OH alcohol and 2500–3000 cm^{-1} for OH acid.

1

(c) Comparison with known spectrum

1

(Exact) match (with known spectrum)

1

[4]

M3. (a) (i) **3**-bromo-**3**-methylpentane ONLY

Must be correct spelling but ignore hyphens and commas

1

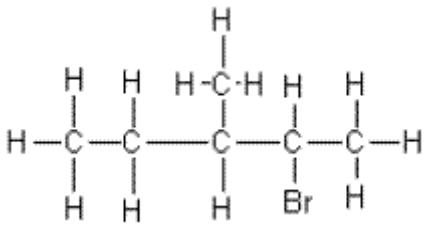
(ii) Electrophilic addition (reaction)

Both words needed

Accept phonetic spelling

1

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



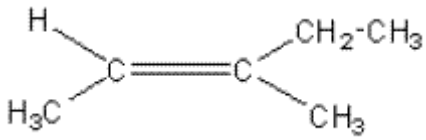
All the bonds must be drawn out but ignore bond angles

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 C_2H_5 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 <u>and</u> this is due to <u>C=C</u>
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}) <u>and</u> does not contain <u>C=C</u>.

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

1

[9]

M4. (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

1

(iii) Splitting molecules using/by water

OR

breaking/splitting/dissociating (C¡VX) bond(s)/using/by water

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

Ignore "compound"

1

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

OR

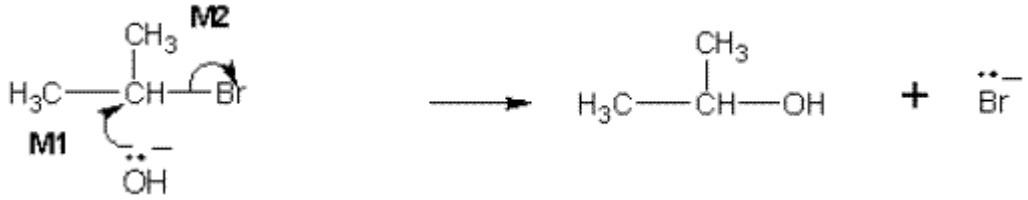
(Heat) energy/enthalpy required/needed/absorbed (at constant pressure) for homolysis of the (C–X/the carbon-halogen) bond

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

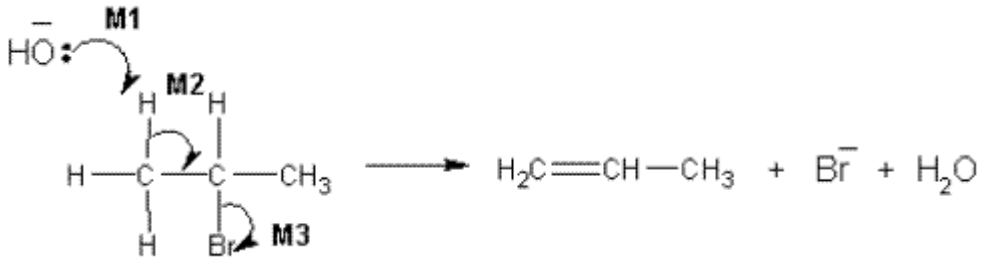
Penalise once only for a line and two dots to show a bond.

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 <u>to the correct</u> 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 <u>original molecule</u>

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** <u>Stated</u> that the spectrum has an <u>absorption/absorbance/ peak in the range 1620 cm^{-1} to 1680</u> (cm^{-1}) or specified <u>correctly in this range</u> from the spectrum

M2 **depends on correct <u>range or wavenumber being specified</u>**

M2 (Infrared absorption) <u>due to C=C OR carbon-carbon double bond</u>

QoL for correct M1 statement which includes both the word absorption (or alternative) <u>and</u> 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]

M5. (a) Pentan-2-one

ONLY but ignore absence of hyphens

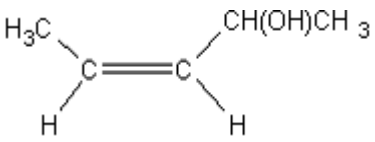
1

(b) Functional group (isomerism)

Both words needed

1

(c) (i)



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

The group needs to be $CHOHCH_3$ but do not penalise poor C–C bonds or absence of brackets around OH

Trigonal planar structure not essential

1

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

OR

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

1

(d)

M1 Tollens' (reagent) *(Credit ammoniacal silver nitrate OR a description of making Tollens')* *(Do not credit Ag^+, $AgNO_3$ or $[Ag(NH_3)_2^+]$ or "the silver mirror test" on their own, but mark M2 and M3)*	**M1** Fehling's (solution) / Benedict's *(Penalise $Cu^{2+}(aq)$ or $CuSO_4$ but mark M2 and M3)*

M2 silver mirror OR black solid or black precipitate	**M2** Red solid/precipitate *(Credit orange or brown solid)*
M3 (stays) colourless OR no (observed) change / no reaction	**M3** (stays) blue OR no (observed) change / no reaction

*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''

1

(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]

M6. (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)

1

(ii) **M1** CO_2 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.

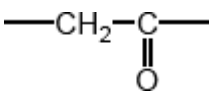
2

[3]

M7.(a) OH alcohols

1

(b) (i) 2.6



Ignore any group on RHS

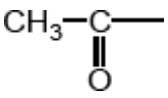
*Must clearly indicate relevant **two** H on a C next to C=O*

On LHS, penalise H or CH or CH_2 or CH_3

Ignore missing trailing bonds or attached R groups

1

(ii) 2.2



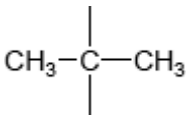
Ignore all groups on RHS

*Must clearly indicate relevant **three** H on C next to C=O*

Ignore missing trailing bonds or attached R group

1

(iii) 1.2



Or in words: two <u>equivalent</u> CH_3 groups

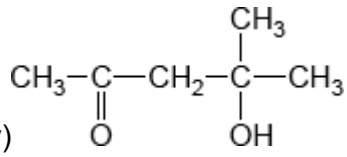
Must clearly indicate two <u>equivalent</u> methyl groups.

Penalise attached H

Ignore missing trailing bonds or attached R groups

1

(iv)



1

[5]