

M1.(a) (i) C

1

(ii) A

1

(iii) D

1

(iv) B

1

(b) **M1** Br<sub>2</sub> **OR** bromine (water) **OR** bromine (in CCl<sub>4</sub> / 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<sub>4</sub> in acid **M2** purple **M3** colourless

**M1** KMnO<sub>4</sub> in alkali / neutral **M2** purple **M3** brown solid

Give appropriate credit for the use of iodine and observations

*No credit for combustion observations*

- (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  $\text{Cl}_2$  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

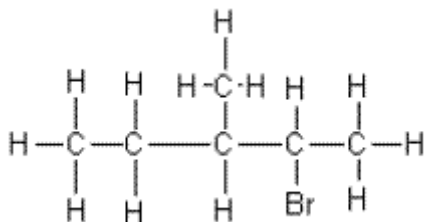
**OR**  $125\text{ }^\circ\text{C} \leq T \leq 600\text{ }^\circ\text{C}$

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

5

[15]

- M2.(a)** OH acid (present in acid not in ester)  
*Allow absorption at 2500–3000 cm<sup>-1</sup> in acid.* 1
- (b) C=O or (absorption at) 1680–1750 cm<sup>-1</sup>  
 (present in acid not in alcohol)  
*Allow correct distinction between 3230–3550 cm<sup>-1</sup> for OH alcohol and 2500–3000 cm<sup>-1</sup> 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

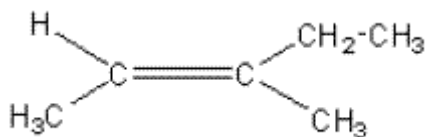


All the bonds must be drawn out but ignore bond angles

- 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 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*

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<sub>1</sub>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

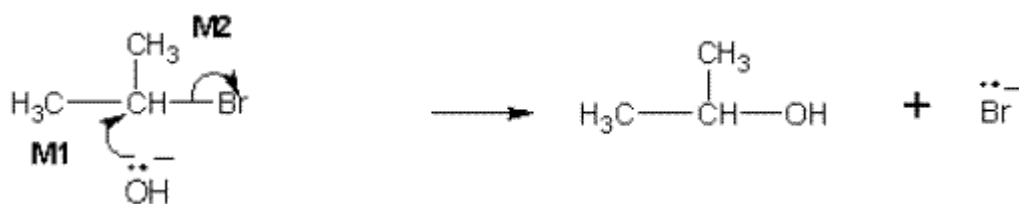
(Heat) energy/enthalpy required/needed/absorbed (at constant pressure) for homolysis of the (C–X/the carbon-halogen) bond

*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<sub>N</sub>1 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*

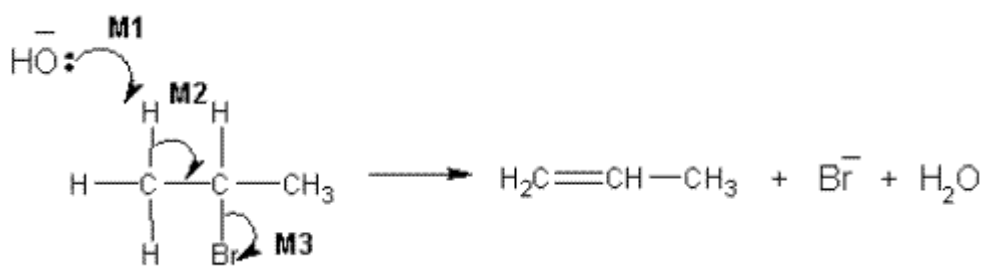
*Penalise once only for a line and two dots to show a bond.*

*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<sup>-1</sup> to 1680 (cm<sup>-1</sup>) 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]

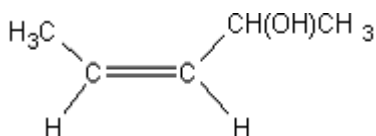
**M5.** (a) Pentan-2-one  
*ONLY but ignore absence of hyphens*

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 CHOCH<sub>3</sub> 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)

<p><b>M1</b> Tollens' (reagent)</p> <p><i>(Credit ammoniacal silver nitrate OR a description of making Tollens')</i></p> <p><i>(Do not credit Ag<sup>+</sup>, AgNO<sub>3</sub> or [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> or "the silver mirror test" on their own, but mark M2 and M3)</i></p>	<p><b>M1</b> Fehling's (solution) / Benedict's</p> <p><i>(Penalise Cu<sup>2+</sup>(aq) or CuSO<sub>4</sub> but mark M2 and M3)</i></p>
--	--



<b>M2</b> <u>silver mirror</u> OR <u>black solid or black precipitate</u>	<b>M2</b> <u>Red solid/precipitate</u> (Credit <u>orange or brown solid</u> )
<b>M3</b> (stays) colourless  OR  no (observed) change / no reaction	<b>M3</b> (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<sup>-1</sup> 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**  $\text{cm}^{-1}$  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**  $\text{cm}^{-1}$  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**  $\text{CO}_2$  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<sup>-1</sup>)

**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<sup>-1</sup>)/1715 (cm<sup>-1</sup>)*

*OR no absorption in the range 1680 – 1750 (cm<sup>-1</sup>)*

*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.*

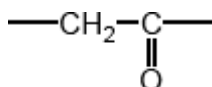
2

[3]

**M7.(a)** OH alcohols

1

(b) (i) 2.6



Ignore any group on RHS

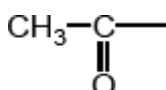
*Must clearly indicate relevant **two** H on a C next to C=O*

On LHS, penalise H or CH or CH<sub>2</sub> or CH<sub>3</sub>

*Ignore missing trailing bonds or attached R groups*

1

(ii) 2.2



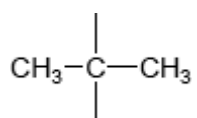
Ignore all groups on RHS

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

*Ignore missing trailing bonds or attached R group*

1

(iii) 1.2



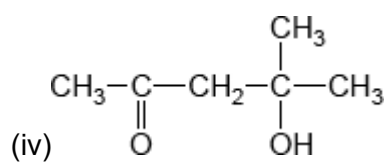
Or in words: two equivalent CH<sub>3</sub> groups

*Must clearly indicate two equivalent methyl groups.*

Penalise attached H

*Ignore missing trailing bonds or attached R groups*

1



1

[5]