OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level Chemistry A

H432/02 Synthesis and analytical techniques

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 24 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **20(a)** and **21**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

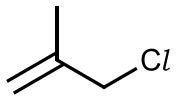
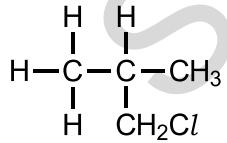
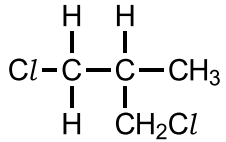
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

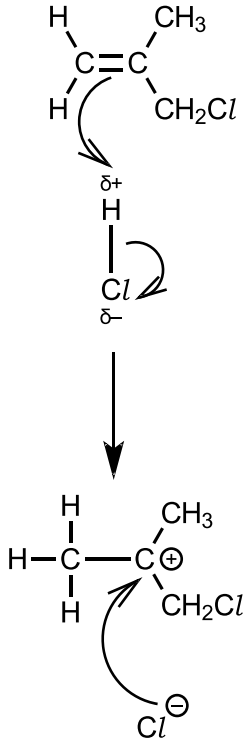
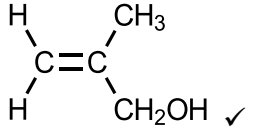
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

SECTION A

Question	Key	Marks	Guidance
1	B	1	
2	B	1	
3	B	1	
4	D	1	
5	A	1	
6	B	1	
7	B	1	
8	B	1	
9	C	1	
10	B	1	
11	D	1	
12	C	1	
13	A	1	
14	D	1	
15	A	1	
	Total	15	

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	C_4H_7Cl ✓	1	
		(ii)	 ✓	1	**DO NOT ALLOW** non-skeletal formulae
		(iii)	(compounds with) the same (molecular) formula **AND** different structures / structural formulae / arrangement of atoms / displayed formulae ✓	1	**ALLOW** same number of atoms of each element **ALLOW** different carbon backbone **DO NOT ALLOW** different spatial arrangement (of atoms)
	(b)		$n = \frac{pV}{RT} = \frac{(100 \times 10^3) \times (1.053 \times 10^{-3})}{8.314 \times 350}$ ✓ n = 0.0362 mol ✓ $M = \frac{m}{n} = \frac{1.321}{0.0362}$ = 36.5 (g mol^{-1}) ✓ *Identity* HCl ✓	4	
	(c)	(i)	From **Reaction 1** =  ✓ compound **B** =  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

Question			Answer	Marks	Guidance
		(ii)	 Curly arrow from C=C to attack the H atom ✓ Correct dipole on H—Cl **AND** curly arrow from bond to Cl ✓ Correct carbocation/carbonium ion with full positive charge shown **AND** correct curly arrow from negative charge of Cl^- to correct carbon atom **OR** correct curly arrow from lone pair of Cl^- to correct carbon atom ✓	**3**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous Curly arrow must start from covalent bonds and not atoms **DO NOT ALLOW** any other partial charges *e.g.* shown on double bond **DO NOT ALLOW** $C^{\delta+}$ for charge on carbonium ion. Curly arrow from Cl^- can start from the negative charge or the lone pair **DO NOT ALLOW** delta negative, *i.e.* C$l^{\delta-}$
		(iii)	because the intermediate/carbocation in the formation of compound **B** is less stable (than the intermediate in the formation of compound **A**) ✓	**1**	
		(iv)	 ✓ (Formation of) white precipitate/solid/suspension **AND** (ppt is) silver chloride/AgCl ✓	**2**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(d)</td><td></td><td>

Use of elemental analysis data

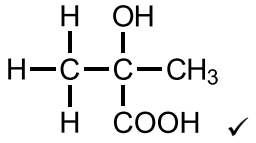
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>%</td><td>46.1</td><td>7.7</td><td>46.2</td></tr>
<tr><td>mol</td><td>3.84</td><td>7.7</td><td>2.89</td></tr>
<tr><td>ratio</td><td>1.33</td><td>2.66</td><td>1</td></tr>
</table>

atom ratio with calculation ✓
empirical formula = $C_4H_8O_3$ ✓

IR spectrum
(very) broad absorption 2500–3300 cm^{-1} (CO**OH**)
AND absorption 1640–1750 cm^{-1} (C=O) ✓
absorption 3450 cm^{-1} (alcohol **–OH**) ✓

Identification

conclusion from data: compound contains –COOH and –OH (empirical formula confirms no other C=O than in COOH) in place of the previous chlorine-containing groups



✓

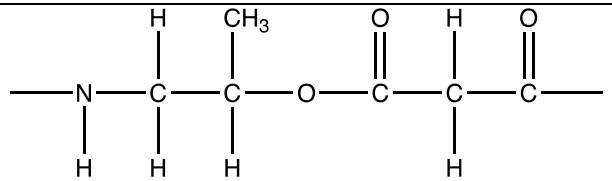
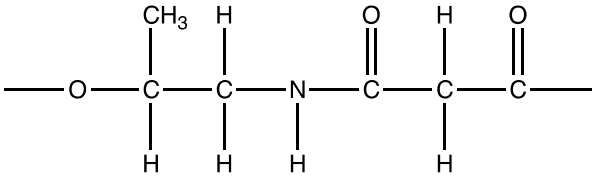
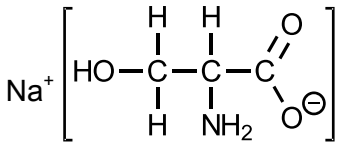
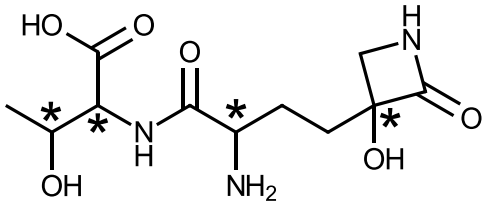
</td><td>5</td><td>

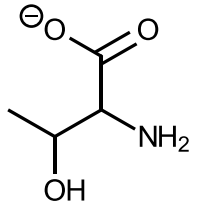
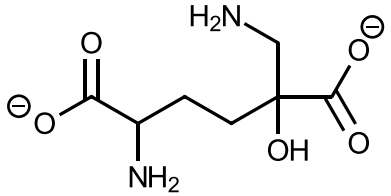
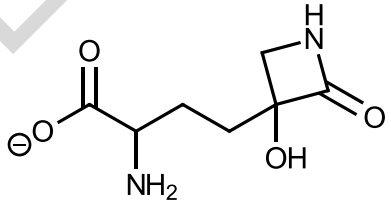
ALLOW any values given within ranges given on Data Sheet

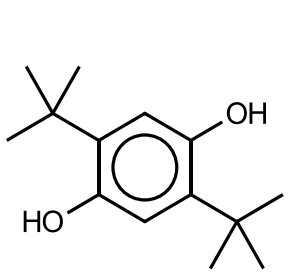
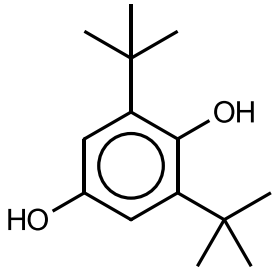
ALLOW correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

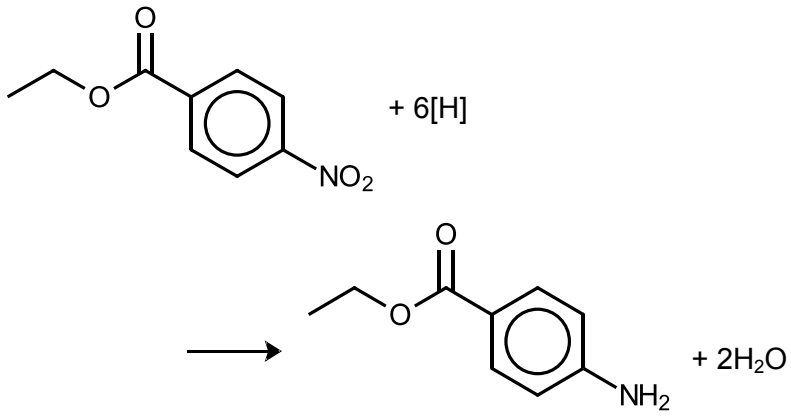
</td></tr>
<tr><td></td><td></td><td></td><td>**Total**</td><td>**20**</td><td></td></tr>
</table>

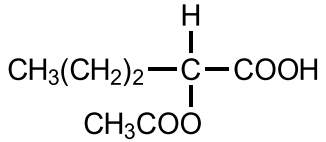
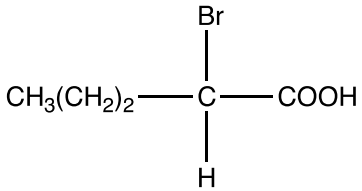
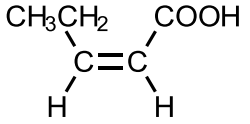
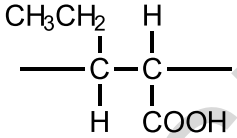
Question			Answer	Marks	Guidance
17	(a)	(i)	**Step 1**: add HCN **OR** H_2SO_4/KCN ✓ $CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$ ✓ **Step 2**: react with H_2/Ni ✓ $CH_3CH(OH)CN + 2H_2 \rightarrow CH_3CH(OH)CH_2NH_2$ ✓	4	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous first mark can be implicit from equation third mark can be implicit from equation if Ni shown as catalyst (*e.g.* above the reaction arrow) **ALLOW** $CH_3CH(OH)CN + 4[H] \rightarrow CH_3CH(OH)CH_2NH_2$
		(ii)	because (compound **D**) forms hydrogen bonds form **with** water ✓ demonstrated through diagram showing: - dashed line between —OH and (:)OH_2 ✓ - dashed line between —NH_2 and (:)OH_2 ✓	3	 dipole and lone pair are **not** required **IGNORE** bond angles Diagram does **not** need to show all of Compound **D** (and **IGNORE** if wrong)

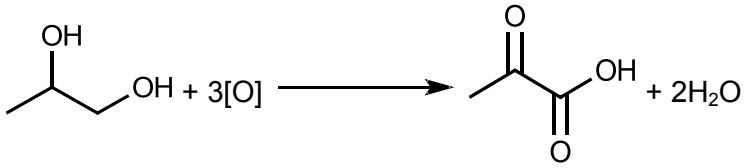
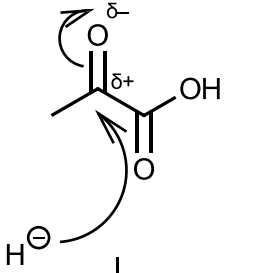
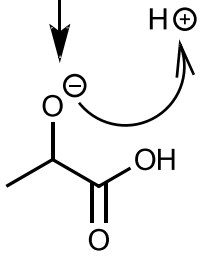
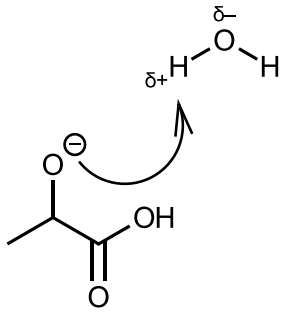
Question			Answer	Marks	Guidance
		(iii)	 **OR**  ester **AND** amide link ✓ rest of structure ✓	**2**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous 'End bonds' **MUST** be shown (solid or dotted) **IGNORE** brackets and/or *n*
	(b)	**(i)**	Atom **A**: 3 bonding pairs **AND** 1 lone pair ✓ (therefore) pyramidal **AND** 107° ✓ Atom **B**: 3 bonding centres (and 0 lone pairs) ✓ (therefore) trigonal planar **AND** 120° ✓	**4**	**ALLOW** 106–108° **ALLOW** 4 bonding pairs but with 1 double/π-bond (therefore 3 bonding centres)
		(ii)	 ✓ filter solution ✓ recrystallise ✓	**3**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous
	(c)	**(i)**	 ✓ for all four	**1**	

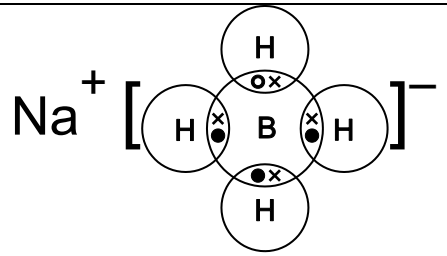
Question			Answer	Marks	Guidance
		(ii)	***Left-hand fragment***  **OR** structure with COOH rather than COO^- ✓ ***Right-hand fragment***  **OR** structure with COOH rather than COO^- ✓✓ Two **OR** three COO^- shown ✓	**4**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW** 1 mark for structure with right-hand ring still intact 
			Total	**21**	

Question			Answer	Marks	Guidance
18	(a)	(i)	  **OR** ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW** disubstituted compound with *tert*-butyl groups adjacent
		(ii)	(The student's friend is correct because) the lone pair of electrons on the oxygen atom(s) ✓ is donated to/partially delocalised into the π system ✓ making quinol more susceptible to electrophilic attack ✓	3	**ALLOW** "the oxygen p-orbital overlaps with…" **ALLOW** diagrammatic answer for 1st and 2nd marks: 1st mark: π system **OR** 6×p orbitals shown 2nd mark: O lone pair **OR** O p-orbital **AND** interaction **ALLOW** undergoes electrophilic substitution more easily if 1st and 2nd marks achieved through diagram, conclusion **must** refer to diagram for 3rd mark
	(b)	(i)	step **1** = (conc.) H_2SO_4 **AND** CH_3CH_2OH ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

Question			Answer	Marks	Guidance
		(ii)	 **BOTH** organic structures ✓ balanced equation ✓	**2**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous
			Total	**7**	

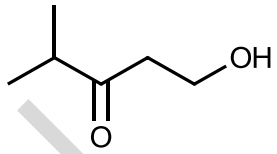
Question			Answer	Marks	Guidance
19	(a)	(i)	**Product from reaction 1:**  ✓ **Product from reaction 2:**  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous
		(ii)	(*E*)-pent-2-enoic acid ✓	1	**ALLOW** "*E*" with or without brackets
		(iii)	compound **H** =  ✓ addition polymer =  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous 'End bonds' **MUST** be shown (solid or dotted) **IGNORE** brackets and/or *n*
		(iv)	combustion for energy production ✓ use as an organic feedstock for the production of plastics and other organic chemicals ✓	2	

Question			Answer	Marks	Guidance
	(b)	(i)	Oxidising agent = acidified (potassium/sodium) dichromate(VI) ✓ **(Oxidation) equation**  ✓ **(Reduction) mechanism**  curly arrow from H^- to $C^{\delta+}$ ✓ dipole **AND** curly arrow from C=O bond to O ✓  intermediate **AND** curly arrow to H^+ ✓	5	**ALLOW** $Cr_2O_7^{2-}$ **OR** $K_2Cr_2O_7$ **OR** $Na_2Cr_2O_7$ for dichromate **ALLOW** H^+ **OR** (conc.) sulfuric acid for "acidified" **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous  **ALLOW** for second stage **IF** H_2O is used it **MUST** show the curly arrow from the intermediate to $H^{\delta+}$ in H_2O **AND** from the O—H bond to the O **IGNORE** product **IGNORE** stereochemistry of intermediate

Question			Answer	Marks	Guidance
		(ii)	 ✓ $1s^2\ 2s^2\ 2p^6$ ✓	2	**IGNORE** inner electron shells for both ions Three different symbols required to identify electrons from different elements **DO NOT ALLOW** [Ne] **OR** [He] $2s^2\ 2p^6$
	(c)		*n*(NaOH) used in titration = 0.150 × 18.80/1000 = 0.00282 (mol) ✓ *n*(H^+/COOH) in 25.0 cm^3 = 0.00282 (mol) **AND** *n*(H^+/COOH) in 250 cm^3 = 0.0282 (mol) ✓ 'Molar' mass of **K** = 1.89/0.0282 = 67.0 g mol^{-1} ✓ **K** must be diprotic ✓ **K** is malic acid/$HOOCCH_2CHOHCOOH$ ✓	5	Determined through realisation that none of the compounds listed have *M* = 67.0 g mol^{-1}
			Total	19	

Question			Answer	Marks	Guidance
20	(a)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correctly labelled diagram of apparatus that works, with no safety problems **AND** Full appreciation of further two steps required to gain pure sample *There is a well-developed diagram which is clear and structured. The information on further purification is detailed and relevant.* **Level 2 (3–4 marks)** Labelled diagram of apparatus but with safety/procedural problems **OR** clear diagram of functional apparatus without labelling **AND** Some details of further purification steps *The diagram presents apparatus that is in the most-part relevant with some correct labelling, and supported by some details of further purification steps.* **Level 1 (1–2 marks)** Diagram of apparatus drawn with no labelling **OR** labelled diagram with significant safety/procedural problems **AND** Few or imprecise details about further purification stages *The diagram is basic and unstructured. Any mention of purification steps is limited to generic term, e.g. 'drying', without relevant detail.*	6	**Indicative scientific points may include:** **Diagram** <u>Includes following components:</u> distillation flask heat source thermometer at outlet (bulb **level** with outlet) still-head water condenser (**correct direction** of water flow) receiving vessel **open** system. **Further purification** Shake and leave to settle in a separating funnel Separate layers by tapping off Add (a small amount of) anhydrous magnesium sulfate/anhydrous calcium chloride to organic layer (in a dry conical flask) (Re)distil the organic layer Collect fraction distilling at (between 150 °C and) 156 °C.

Question			Answer	Marks	Guidance
			0 marks No response or no response worthy of credit.		
	(b)		Lack of (further) effervescence ✓	**1**	**ALLOW** fizzing/bubbling stops
	(c)		Take samples from reaction mixture at regular intervals ✓ Spot/run on a TLC plate, alongside cyclohexanol (and cyclohexanone) controls ✓	**2**	**ALLOW** "frequent" for "regular" **ALLOW** measure/compare R_f value to cyclohexanol **IGNORE** reference to solvent or visualising chemicals/UV
	(d)		React (sample of distillate) with 2,4-dinitrophenylhydrazine ✓ recrystallise **AND** determine the melting point ✓ Compare melting point to known/library value for cyclohexanone (derivative) ✓	**3**	**ALLOW** (2,4-)DNPH/Brady's reagent
			Total	**12**	

Question	Answer	Marks	Guidance
21*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Structure correct **AND** Analysed all ^{1}H NMR signals with at least two supporting statements made. *The analysis is clear and logically structured. The supporting statements are relevant to the correct structure drawn.* **Level 2 (3–4 marks)** Structure has correct molecular formula **AND** C=O **AND** OH but in incorrect positions **AND** Analysed at least three ^{1}H NMR signals with one or two supporting statements made *The analysis is presented with some structure. The supporting statements are in the most-part relevant to the structure drawn.* **Level 1 (1–2 marks)** Structure has correct molecular formula **AND** C=O **OR** OH but in incorrect positions **AND** Analysed at least two ^{1}H NMR signals with no or one supporting statements made *The analysis is basic and communicated in an unstructured way. The relationship of the supporting evidence to the structure may not be clear.*	6	**Indicative scientific points may be included:** **Structure**  **L =** **^{1}H NMR spectrum** δ = 3.8 ppm, triplet, 2H CH_2—**CH_2—O** δ = 3.7 ppm, singlet, 1H O—**H** δ = 3.1 ppm, triplet, 2H CH_2—**CH_2C=O** δ = 2.7 ppm, septet, 1H $(CH_3)_2C$**HC=O** δ = 1.0 ppm, doublet, 6H **$(CH_3)_2$**CH **Supporting statements** δ = 3.7 ppm lost after D_2O, indicating —O**H** δ = 213 ppm in ^{13}C NMR but no δ = 9–10 ppm in ^{1}H NMR so ketone, **not** aldehyde $M_r(C_3H_6O)$ = 58 116/58 = 2 → $C_6H_{12}O_2$

Question			Answer	Marks	Guidance
			0 marks No response or no response worthy of credit.		
			Total	**6**	

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