

GCE

Chemistry A

Unit **F324**: Rings, Polymers and Analysis

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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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

Subject-specific Marking Instructions**INTRODUCTION**

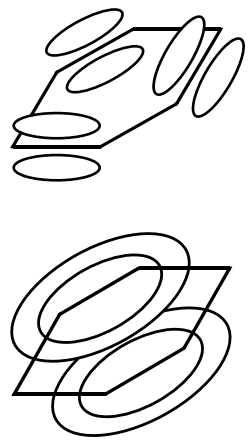
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

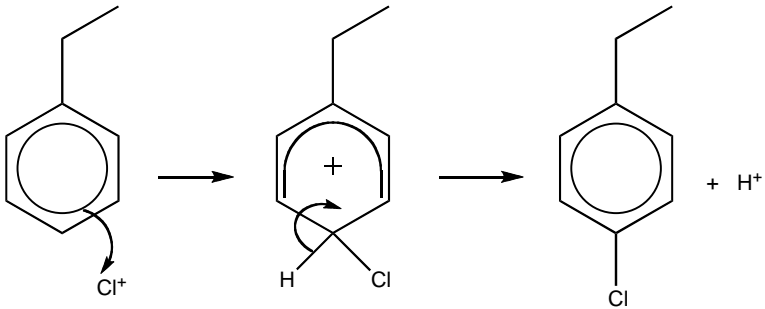
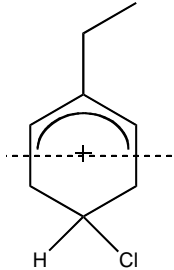
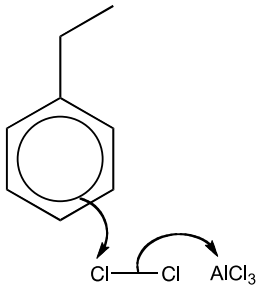
- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

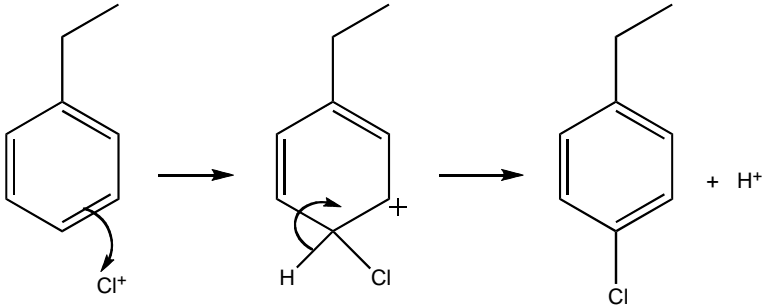
You should ensure that you have copies of these materials.

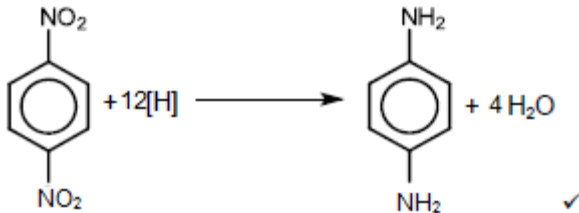
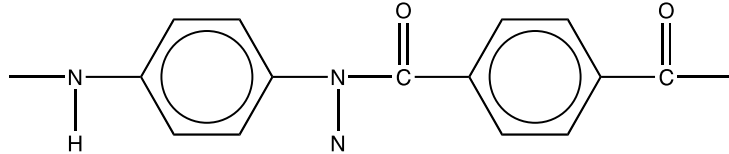
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New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

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

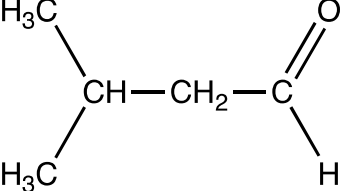
Question			Answer	Marks	AO element	Guidance
1	(a)	(i)		2	AO1	<p>Diagrams must show the full ring Labels not required</p> <p>Diagram shows correct position of localised π-bonds/π-electrons OR correct position of p-orbital overlap</p> <p>Diagram shows correct position of delocalised π-bonds/π-electrons OR correct position of p-orbital overlap</p> <p>IGNORE C=C in diagram IGNORE initial diagrams showing p-orbitals</p>
		(ii)	<p>Maximum of 3 marks</p> <p>Bond lengths: up to 2 marks All carbon-carbon bonds the same length ✓</p> <p>Bond length intermediate/between (short) C=C and (long) C-C ✓</p> <p>Enthalpy change of hydrogenation: up to 2 marks ΔH <u>hydrogenation</u> different from that expected ✓</p> <p>ΔH less exothermic than expected (when compared to ΔH hydrogenation for cyclohexene) ✓</p>	3	AO1 AO1 AO1	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE any reference to reactivity</p> <p>DO NOT ALLOW ΔH halogenation/hydration</p>
	(b)	(i)	6 ✓	1	AO2	

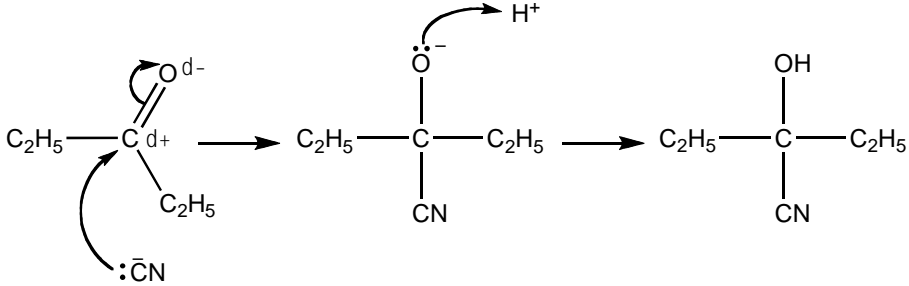
Question	Answer	Marks	AO element	Guidance
(b) (ii)	<p>$\text{AlCl}_3 + \text{Cl}_2 \rightarrow \text{AlCl}_4^- + \text{Cl}^+$ ✓</p>  <p>Curly arrow from π bond to Cl^+ ✓</p> <p>Correct intermediate ✓</p> <p>Curly arrow from C-H bond back to reform ring ✓</p> <p>$\text{H}^+ + \text{AlCl}_4^- \rightarrow \text{AlCl}_3 + \text{HCl}$ ✓</p> <p>Note: 1st curly arrow should start within the ring or on the ring</p>	5	AO1	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>NOTE: If Br^+ is used, DO NOT ALLOW 1st mechanism mark but other marks available by ECF</p> <p>NOTE Absence of C_2H_5 OR wrong position of C_2H_5 loses intermediate mark</p> <p>DO NOT ALLOW the following intermediate:</p>  <ul style="list-style-type: none"> π-ring must be more than halfway way down <p>AND</p> <ul style="list-style-type: none"> Arc must be the right way up (i.e. gap towards C-Cl) <p>ALLOW + sign anywhere within hexagon of intermediate</p> <p>ALLOW mechanism with $\text{Cl}-\text{Cl} \cdots \text{AlCl}_3$ for 1st two marks, i.e.</p> 

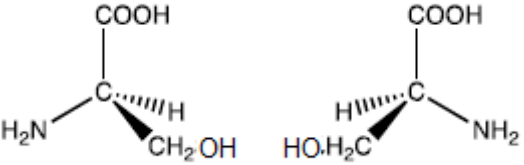
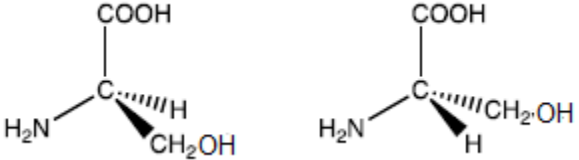
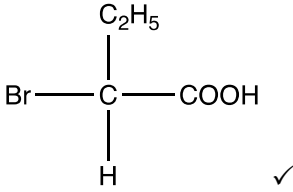
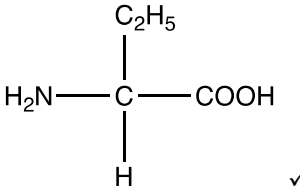
Question	Answer	Marks	AO element	Guidance
	<p>NOTE: ALLOW mechanism using Kekulé structures, i.e.</p> 			Refer alternative mechanisms to TL for discussion.
(iii)	<p>HNO₃ AND H₂SO₄ ✓</p>	1	AO3	<p>IGNORE temperature IGNORE catalyst</p> <p>'concentrated' not required for HNO₃ or H₂SO₄ but DO NOT ALLOW dilute HNO₃ or dilute H₂SO₄</p>
(iv)	<p>IF answer = 61.2% award 3 marks</p> <p>moles of ethylbenzene used = $2.65/106 = 0.025(0)$ (mol) ✓</p> <p>moles of B formed = $2.31/151 = 0.0153$ (mol) ✓</p> <p>yield = $0.0153/0.0250 \times 100 = 61.2\%$ ✓</p>	3	<p>AO2</p> <p>AO2</p> <p>AO2</p>	<p>0.0250 mol is exact calculator value</p> <p>0.0153 mol must be to at least 3sf (calculator value 0.015298013)</p> <p>The final answer must be to 3 SF (calculator value gives 61.1920529%) (rounding of moles of B gives 61.2% exactly)</p> <p>ALLOW ECF from incorrect <i>M_r</i> or moles unless the yield is > 100%</p>
	Total	14		

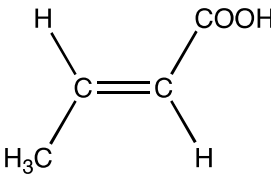
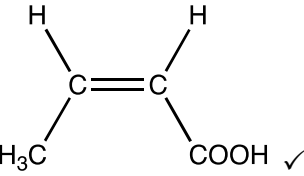
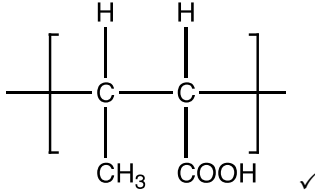
Question		Answer	Marks	AO element	Guidance
2	(a)	<u>nitrogen</u> electron pair OR <u>nitrogen</u> lone pair accepts a proton/H ⁺ ✓	1	AO1	DO NOT ALLOW nitrogen/N lone pair accepts hydrogen (proton/H ⁺ required) ALLOW nitrogen donates an electron pair/lone pair to H ⁺ IGNORE NH ₂ group donates electron pair
	(b) (i)	Sn AND concentrated HCl ✓	1	AO3	IGNORE temperature and reaction type/purpose of reagents
	(ii)		1	AO2	ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous DO NOT ALLOW H ₂ instead of [H]
	(c) (i)	monomers join/bond/add/react/form polymer/form chain AND form another product/small molecule/H ₂ O/HCl ✓	1	AO1	IGNORE 'two' when referring to monomers, <i>i.e.</i> (two) monomers...
	(ii)	 amide link ✓ correct structure ✓	2	AO2 AO2	ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous ALLOW 'terminal' —NH— at other end 'End bonds' MUST be shown (solid or dotted) IGNORE brackets and/or <i>n</i> ALLOW CONH for amide link

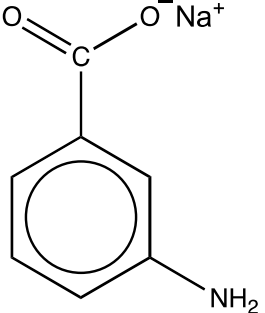
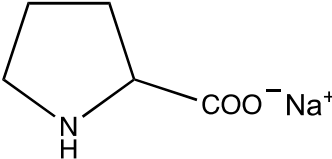
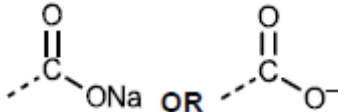
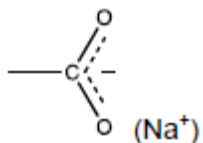
Question		Answer	Marks	AO element	Guidance	
	(d)	(i)	$C_8H_{15}NO$ ✓	1	AO2	ALLOW any order of elements
		(ii)	$H_2N(CH_2)_6NH_2$ ✓ $HOOC(CH_2)_8COOH$ ✓	2	AO2 AO2	ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous ALLOW acyl chloride, $ClOC(CH_2)_8COCl$
			Total	9		

Question	Answer	Marks	AO element	Guidance
3 (a)	<p>M1 (¹³C NMR spectrum indicates) four types of carbon ✓</p> <p>M2 (Tollens' test shows) compound D is an aldehyde ✓</p> <p>M3 Correct structure ✓</p> 	3	<p>AO1</p> <p>AO2</p> <p>AO2</p>	<p>ALLOW 4 carbon environments</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>NOTE: Correct structure also scores M2 (aldehyde shown in structure)</p> <p>ALLOW 3-methylbutanal (2 marks)</p> <p>NOTE: Ketone with four carbon environments i.e. methylbutanone (Maximum 2 marks possible: M1 and M3)</p>

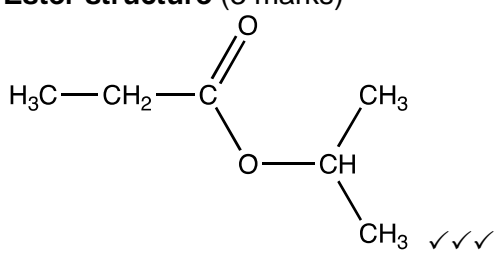
Question	Answer	Marks	AO element	Guidance
(b)	<p>Correct structure of compound E (pentan-3-one) ✓</p>  <p>curly arrow from :CN^- to $\text{C}(\delta^+)$ of $\text{C}=\text{O}$ group ✓</p> <p>dipole correct AND curly arrow from $\text{C}=\text{O}$ bond to $\text{O}(\delta^-)$ ✓</p> <p>Correct intermediate with negative charge on O AND Curly arrow from O^- to H^+ ✓</p>	4	<p>AO2</p> <p>AO2</p> <p>AO1</p> <p>AO1</p>	<p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>IF structure E is incorrect 3 marks can be scored for the mechanism e.g. apply ECF to error in structure e.g. CH_2 missing from the chain</p> <p>First curly arrow must come from either lone pair on :CN^- or '$-$' charge on :CN^- DO NOT ALLOW lone pair and/or negative charge on nitrogen atom</p> <p>Curly arrow must come from either lone pair on O or negative charge on O</p> <p>ALLOW curly arrow from O^- to $\text{H}\delta^+$ of H_2O Dipole on H_2O must be shown.</p> <p>IGNORE other products</p>
	Total	7		

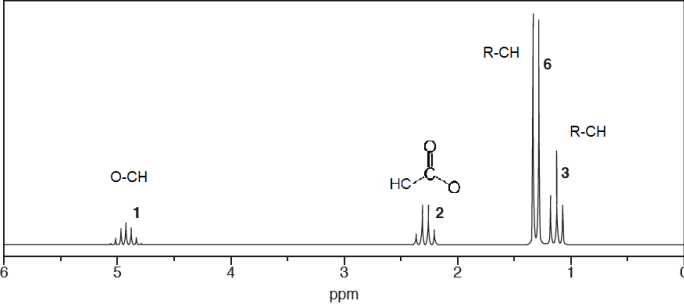
Question	Answer	Marks	AO element	Guidance
4 (a)	<p>M1 Mirror images around a tetrahedral carbon atom ✓</p>  <p>M2 The four correct groups with correct connectivity ✓</p>	2	AO1 AO2	<p>3-D diagrams must contain 1 'out wedge' and 1 'in wedge'/dotted line AND 2 lines in plane of paper</p> <p>ALLOW 2 'out wedges', 1 'in wedge' and 1 line in plane of paper.</p> <p>ALLOW the same 3-D structure repeated with two groups 'swapped'. After rotation the second isomer is a mirror image of the first.</p>  <p>Connectivity: the chiral carbon must be linked to the C of the COOH AND the C of the CH₂OH AND the N of NH₂.</p>
(b)	<p>M1 Compound F</p>  <p>M2 Compound G</p> 	6	AO2	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>IGNORE labels for M1, M2, M3 and M4</p> <p>ALLOW ECF for the following conversions: F → G (F must have correct molecular formula) H → I (I must have correct empirical formula)</p>

Question	Answer	Marks	AO element	Guidance
	<p>M3 Compound H</p> <div style="text-align: center;">  </div> <p>OR</p> <div style="text-align: center;">  </div> <p>M4 Polymer I</p> <div style="text-align: center;">  </div> <p>M5 Formation of F is an (electrophilic) addition reaction ✓</p> <p>M6 Formation of G is a (nucleophilic) substitution reaction ✓</p>		<p>AO2</p> <p>AO2</p> <p>AO2</p> <p>AO1</p> <p>AO1</p>	<p>C=C must be shown in H</p> <p>ALLOW multiple repeat units but must be full repeat units ALLOW end bonds shown as DO NOT ALLOW if structures have no end bonds IGNORE brackets unless they are used to pick out the repeat unit from a polymer chain IGNORE n</p> <p>ALLOW reaction with HBr is an addition reaction</p> <p>DO NOT ALLOW nucleophilic addition</p> <p>ALLOW reaction with NH₃ is a substitution reaction</p> <p>DO NOT ALLOW electrophilic substitution</p>

Question	Answer	Marks	AO element	Guidance
(c)	 <p>1 mark for correct structure with COOH or COO⁻Na⁺ ✓</p>  <p>1 mark for correct structure with COOH or COO⁻Na⁺ ✓</p> <p>1 mark for both structures shown with COO⁻ ✓</p>	3	AO2 AO2 AO2	<p>For both structures, ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>Note: If there are more than two structures shown, credit any correct structures and IGNORE incorrect structures</p> <p>DO NOT ALLOW -COO-Na (covalent bond) (penalise once only)</p> <p>ALLOW -COO⁻ ALLOW -COONa OR</p>  <p>ALLOW delocalised carboxylate</p> 
	Total	12		

Question	Answer	Marks	AO element	Guidance
5 (a)	<p>Throughout, ALLOW formulae OR correct names</p> <p>-----</p> <p>M1 react $(\text{CH}_3)_3\text{CCHO}$ with $\text{H}_2\text{SO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ AND heat/reflux ✓</p> <p>M2 Equation: $(\text{CH}_3)_3\text{CCHO} + [\text{O}] \rightarrow (\text{CH}_3)_3\text{CCOOH}$ ✓</p> <p>M3 react $(\text{CH}_3)_3\text{CCHO}$ with NaBH_4 ✓</p> <p>M4 Equation: $(\text{CH}_3)_3\text{CCHO} + 2[\text{H}] \rightarrow (\text{CH}_3)_3\text{CCH}_2\text{OH}$ ✓</p> <p>M5 react $(\text{CH}_3)_3\text{CCOOH}$ with $(\text{CH}_3)_3\text{CCH}_2\text{OH}$ ✓ AND acid catalyst/H_2SO_4</p> <p>M6 Equation: $(\text{CH}_3)_3\text{CCOOH} + (\text{CH}_3)_3\text{CCH}_2\text{OH} \rightarrow$ $(\text{CH}_3)_3\text{CCOOCH}_2\text{C}(\text{CH}_3)_3 + \text{H}_2\text{O}$ ✓</p> <p>M7 <u>reflux</u> in either (M1) or (M5) or <u>catalyst</u> used in (M5) ✓ QWC must spell catalyst or reflux correctly</p>	7	<p>AO3</p> <p>AO2</p> <p>AO3</p> <p>AO2</p> <p>AO3</p> <p>AO2</p> <p>AO1</p>	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC ALLOW $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}$ or $\text{H}_2\text{SO}_4/\text{Na}_2\text{Cr}_2\text{O}_7$ ALLOW acidified dichromate</p> <p>ALLOW LiAlH_4 as alternative to NaBH_4</p> <p>If both already correctly identified, ALLOW 'carboxylic acid and alcohol' ALLOW conc H_2SO_4 DO NOT ALLOW dilute or $\text{H}_2\text{SO}_4(\text{aq})$ ALLOW HCl IGNORE HNO_3</p>

Question		Answer	Marks	AO element	Guidance																				
5	(b)	<p>similar compounds have similar retention times ✓</p> <p>no reference values ✓</p>	2	AO1 AO1	<p>ALLOW same retention times</p> <p>ALLOW correct description of retention time</p> <p>ALLOW leave the column at the same time</p> <p>ALLOW relative solubilities/partition/adsorption will be very similar</p> <p>IGNORE R_f values</p> <p>ALLOW no data book values (of retention times)</p>																				
	(c)	<p>Elemental analysis and molecular formula (2 marks)</p> <p>Use of percentages to find empirical formula = C₃H₆O ✓</p> <p>Relative molecular mass from mass spectrum = 116 AND Molecular formula = C₆H₁₂O₂ ✓</p> <p>Ester structure (3 marks)</p>  <p style="text-align: right;">✓✓✓</p>	2 3	AO2 ×2 AO2 ×3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC. CHECK SPECTRUM</p> <table border="1" data-bbox="1377 606 2072 750"> <thead> <tr> <th>Element</th> <th>%</th> <th>A_r</th> <th>moles</th> <th>ratio</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>62.07</td> <td>12</td> <td>5.173</td> <td>3</td> </tr> <tr> <td>H</td> <td>10.34</td> <td>1</td> <td>10.34</td> <td>6</td> </tr> <tr> <td>O</td> <td>27.59</td> <td>16</td> <td>1.724</td> <td>1</td> </tr> </tbody> </table> <p>Alternative method: carbon: $(116 \times 62.07/100)/12 = 6$ hydrogen: $(116 \times 10.34/100)/1 = 12$ oxygen: $(116 \times 27.59/100)/16 = 2$</p> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>If not fully correct award marks as follows:</p> <p>If the structure is any ester with molecular formula C₆H₁₂O₂, e.g. CH₃COOCH₂CH(CH₃)₂ (one mark)</p> <p>If the ester link is reversed i.e. (CH₃)₂CHCOOCH₂CH₃ (two marks)</p> <p>Ignore any name</p>	Element	%	A _r	moles	ratio	C	62.07	12	5.173	3	H	10.34	1	10.34	6	O	27.59	16	1.724	1
Element	%	A _r	moles	ratio																					
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Question	Answer	Marks	AO element	Guidance																									
	<p>NMR analysis (4 marks)</p> <p>M1 Multiplet/heptet/peak at δ 4.9/3.9 is due to HC-O ✓</p> <p>M2 Quartet/peak at (δ) 2.3 is due to HC-C=O ✓</p>	4	<p>AO2</p> <p>AO2</p>	<p>NOTE: Each peak can be identified from:</p> <ul style="list-style-type: none"> • its δ value: ± 0.2 ppm • a range • its relative peak area • its splitting <p>Check annotated spectrum or table</p>  <table border="1" data-bbox="1377 826 2069 1120"> <thead> <tr> <th>Chemical shift/ppm</th> <th>Relative peak area</th> <th>Splitting pattern</th> <th>Type of proton</th> <th>Adjacent protons</th> </tr> </thead> <tbody> <tr> <td>1.2</td> <td>3</td> <td>triplet</td> <td>R-CH</td> <td>2</td> </tr> <tr> <td>1.3</td> <td>6</td> <td>doublet</td> <td>R-CH</td> <td>1</td> </tr> <tr> <td>2.3</td> <td>2</td> <td>quartet</td> <td>HC-C=O</td> <td>3</td> </tr> <tr> <td>4.9</td> <td>1</td> <td>multiplet</td> <td>O-CH</td> <td>6</td> </tr> </tbody> </table>	Chemical shift/ppm	Relative peak area	Splitting pattern	Type of proton	Adjacent protons	1.2	3	triplet	R-CH	2	1.3	6	doublet	R-CH	1	2.3	2	quartet	HC-C=O	3	4.9	1	multiplet	O-CH	6
Chemical shift/ppm	Relative peak area	Splitting pattern	Type of proton	Adjacent protons																									
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2.3	2	quartet	HC-C=O	3																									
4.9	1	multiplet	O-CH	6																									

Question	Answer	Marks	AO element	Guidance
	<p>M3 (CH₂CH₃)</p> <p>Triplet/peak (at δ 1.2) AND quartet/peak (at δ 2.3) = CH₂CH₃ OR Triplet/peak (at δ 1.2) shows 2 adjacent Hs/protons = CH₂CH₃ OR Quartet/peak (at δ 2.3) shows 3 adjacent Hs/protons = CH₂CH₃</p> <p>NOTE: QWC – triplet or quartet must be spelled correctly in the correct context for M3 ✓</p>		AO2	<p>ALLOW CH₃CH₂ described as CH₃ and 2 adjacent H OR CH₂ and 3 adjacent H</p> <p>For QWC, ALLOW quadruplet for quartet</p>
	<p>M4</p> <p>Multiplet/heptet/peak (at δ 4.9/3.9) shows 6 adjacent H/two CH₃ groups OR Doublet/peak (at δ 1.3) shows one adjacent H</p> <p style="text-align: right;">✓</p>		AO2	
	Total	18		

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