
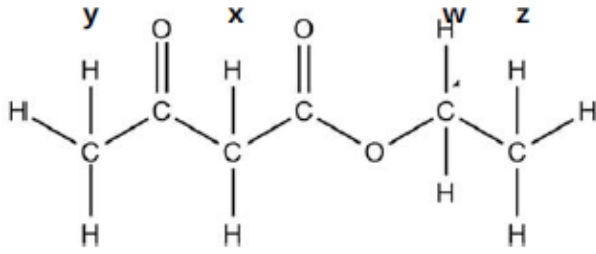


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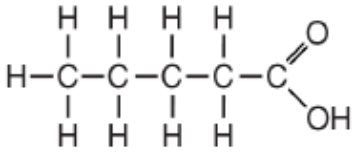
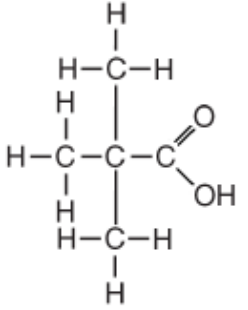
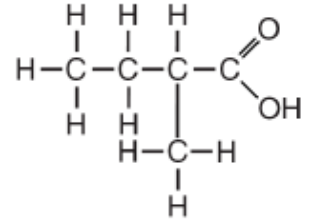
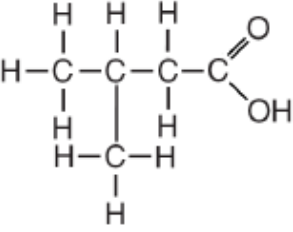
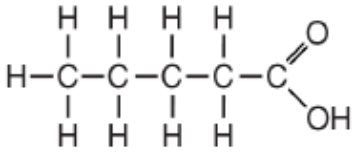
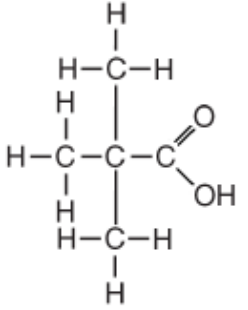
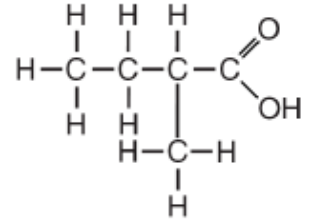
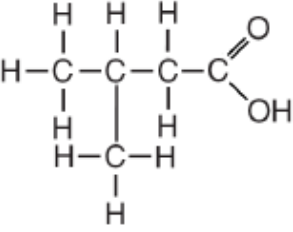
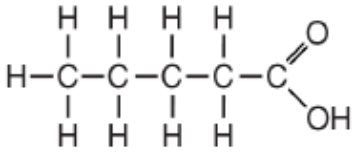
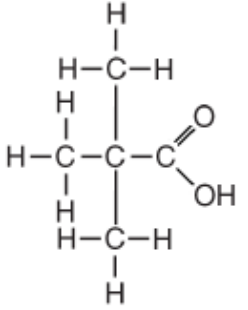
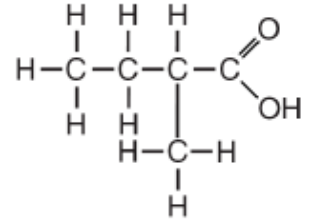
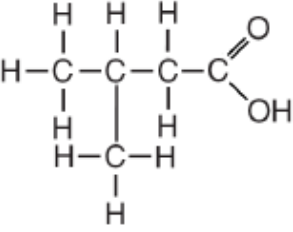
NMR

Past paper questions booklet – MARK SCHEME

International A Level Chemistry

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	 <p>(2)</p> <p>All 4 peaks correctly matched scores both marks 2 or 3 peaks correctly matched scores 1 mark 0 or 1 peak correctly matched scores 0 marks</p>	NOTE Allow labels to/near to carbon of correct group	2

Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	<p>4.2 ppm quartet due to 3 hydrogen (atoms) on adjacent carbon (1)</p> <p>1.3 ppm triplet due to 2 hydrogen (atoms) on adjacent carbon (1)</p>	<p>Allow 'due to adjacent CH₃'</p> <p>Allow 'due to adjacent CH₂'</p> <p>If neither mark awarded can score 1 for correct reference to n+1 rule</p> <p>If no reference to splitting patterns then allow 1 for correctly identifying both sets of adjacent hydrogens</p>	2

Question Number	Answer	Additional guidance	Mark								
17(a)	<ul style="list-style-type: none"> • Structure A (1) • Structure B (1) • Structure C (1) • Structure D (1) 	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: center;">A</th> <th style="width: 50%; text-align: center;">B</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: middle;">  </td> <td style="text-align: center; vertical-align: middle;">  </td> </tr> <tr> <th style="text-align: center;">C</th> <th style="text-align: center;">D</th> </tr> <tr> <td style="text-align: center; vertical-align: middle;">  </td> <td style="text-align: center; vertical-align: middle;">  </td> </tr> </tbody> </table> <p style="margin-top: 10px;"> Allow condensed or skeletal formulae If Structure B has not been scored allow this structure as a correct answer for Structure D Penalise OH-C connectivity once only to horizontal bonds Ignore connectivity on vertical bonds to OH and all bonds to CH₃ groups. Penalise incorrect names also given once only </p>	A	B			C	D			(4)
A	B										
											
C	D										
											

Question Number	Answer	Additional guidance	Mark												
17(b)(i)	<ul style="list-style-type: none"> • 3, 4 or 5 correct boxes (1) • 6, 7 or 8 correct boxes (2) • Nine correct boxes (3) 	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>b</th> <th>c</th> <th>d</th> </tr> </thead> <tbody> <tr> <td>2</td> <td>2</td> <td>3</td> </tr> <tr> <td>2.7 – 4.2</td> <td>1.5 – 2.9</td> <td>1.5 – 2.9</td> </tr> <tr> <td>triplet</td> <td>triplet</td> <td>singlet</td> </tr> </tbody> </table> <p>Allow a value or range within the range</p> <p>Allow triple / single 3lines / 1 line</p>	b	c	d	2	2	3	2.7 – 4.2	1.5 – 2.9	1.5 – 2.9	triplet	triplet	singlet	(3)
b	c	d													
2	2	3													
2.7 – 4.2	1.5 – 2.9	1.5 – 2.9													
triplet	triplet	singlet													

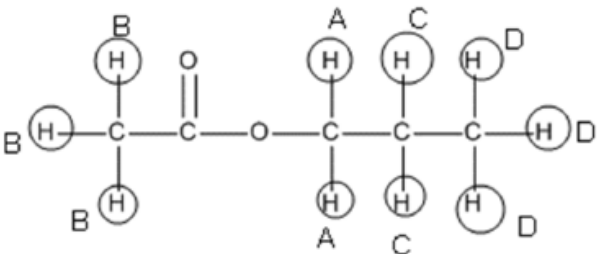
Question Number	Answer	Additional guidance	Mark
17(b)(ii)	<ul style="list-style-type: none"> • Five / 5 (peaks) 		(1)

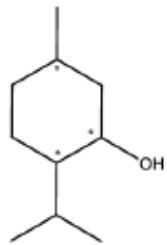
Question Number	Answer	Additional Guidance	Mark
17(c)	<p>• Monomer 1</p> $\begin{array}{ccccccc} & & \text{H} & & \text{H} & & \\ & & & & & & \\ \text{H} & - & \text{O} & - & \text{C} & - & \text{C} & - & \text{O} & - & \text{H} \\ & & & & & & \\ & & \text{H} & & \text{H} & & \end{array}$ <p>(1)</p> <p>• Monomer 2</p> $\begin{array}{ccccccc} & & \text{O} & & \text{H} & & \text{O} & & \\ & & & & & & & & \\ \text{H} & - & \text{O} & - & \text{C} & - & \text{C} & = & \text{C} & - & \text{O} & - & \text{H} \\ & & & & & & & & & & & & \\ & & & & & & \text{H} & & & & & & \end{array}$ <p>or</p> $\begin{array}{ccccccc} & & \text{O} & & \text{H} & & \text{O} & & \\ & & & & & & & & \\ \text{Cl} & - & \text{C} & - & \text{C} & = & \text{C} & - & \text{C} & - & \text{Cl} \\ & & & & & & & & & & \\ & & & & & & \text{H} & & & & \end{array}$ <p>(1)</p>	<p>Allow monomers in either order Allow any combination of structural or displayed formulae / skeletal formulae Allow OH</p> <p>Ignore bond lengths and bond angles</p> <p>Penalise OH-C on left of molecules once only Penalise missing H from carbon chain displayed formulae once only</p> <p>Accept cis isomers</p>	(2)

Question Number	Answer	Additional Guidance	Mark
17(d)(i)	<ul style="list-style-type: none"> $C_5H_{10}O_2$ 	Allow symbols in any order Ignore any working Ignore + charge	(1)

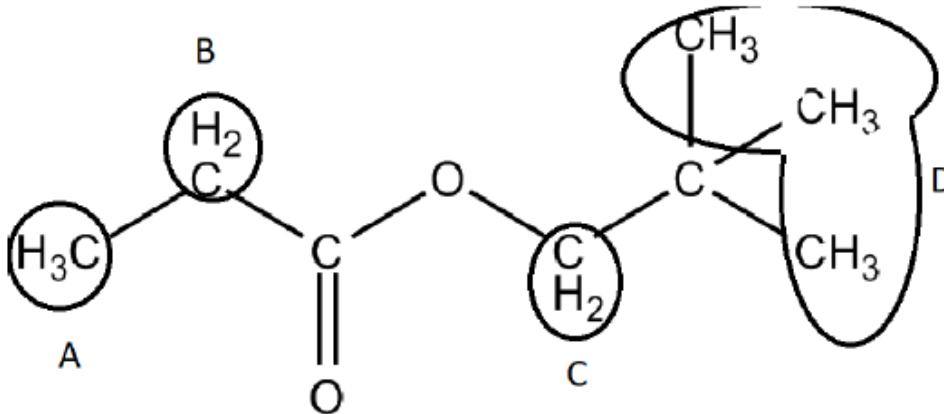
Question Number	Answer	Additional Guidance	Mark
17(d)(ii)	<ul style="list-style-type: none"> E is not a carboxylic acid or does not contain COOH (group) 	If name and formula are given, both must be correct Allow E is not an acid Do not award additional functional groups	(1)

Question Number	Answer	Additional Guidance	Mark
17(d)(iii)	<ul style="list-style-type: none"> E is an ester 	Ignore saturated / -COO- / C=O Do not award additional functional groups	(1)

Question Number	Answer	Additional Guidance	Mark
17 (d)(iv)	<ul style="list-style-type: none"> structure of E 2 or 3 proton environments correct 4th proton environment correct 	<p>Example of structure:</p> <p>(1)</p>  <p>(1)</p> <p>(1)</p> <p>Protons can be circled and labelled or just labelled Allow labels using data from the table</p> <p>Only 1 proton from each group needs to be labelled</p> <p>Allow whole groups to be labelled, including the carbon atom</p>	(3)

Question Number	Correct Answer	Mark
8 (a)	<p>The only correct answer is C (3)</p>  <p><i>A is incorrect as menthol has 3 chiral carbon atoms</i> <i>B is incorrect as menthol has 3 chiral carbon atoms</i> <i>D is incorrect as menthol has 3 chiral carbon atoms</i></p>	1

Question Number	Correct Answer	Mark
8 (b)	<p>The only correct answer is B (Q)</p> <p><i>A is incorrect as this carbon would produce a peak between 0 and 60 ppm</i> <i>C is incorrect as this carbon would produce a peak between 0 and 60 ppm</i> <i>D is incorrect as this carbon would produce a peak between 0 and 60 ppm</i></p>	1

Question Number	Acceptable Answers	Additional Guidance	Mark
17(c)(i)	 <p>The diagram shows the chemical structure of 2-methylbutanoic acid. The proton environments are labeled as follows: <ul style="list-style-type: none"> A: The methyl group of the carboxylic acid part, circled. B: The methylene group of the carboxylic acid part, circled. C: The methylene group of the ester part, circled. D: The three methyl groups of the ester part, enclosed in a hand-drawn oval. </p>	<p>Labels B C and D can be used interchangeably as long as the three proton environments are identified correctly.</p> <p>Allow 3 methyl groups to be circled individually but with a single label / labels pointing to all 3</p>	1

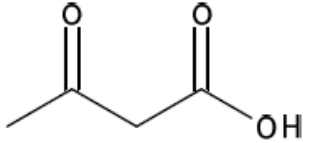
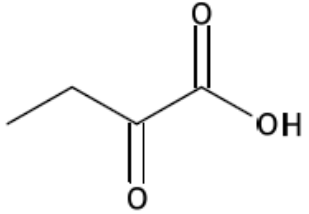
Question Number	Acceptable Answers	Additional Guidance	Mark															
17(c)(ii)	<table border="1"> <thead> <tr> <th>Hydrogen environment</th> <th>Splitting pattern of peak</th> <th>Relative peak area</th> </tr> </thead> <tbody> <tr> <td>(A)</td> <td>(triplet)</td> <td>(3)</td> </tr> <tr> <td>B</td> <td>quartet</td> <td>2</td> </tr> <tr> <td>C</td> <td>singlet</td> <td>2</td> </tr> <tr> <td>D</td> <td>singlet</td> <td>9</td> </tr> </tbody> </table> <p>Note : allow 'quadruplet' as alternative for quartet / 'single' as alternative for singlet</p> <p>Do not award 'quadrat'</p>	Hydrogen environment	Splitting pattern of peak	Relative peak area	(A)	(triplet)	(3)	B	quartet	2	C	singlet	2	D	singlet	9	<p>1 mark for each row.</p> <p>But If two or more rows are incorrect then award whichever of these alternatives is higher Allow 2 marks for 3 correct splitting patterns.</p> <p>OR</p> <p>Allow 1 mark for 3 correct peak areas.</p> <p>OR</p> <p>Allow 1 mark for correct row</p> <p>marked consequentially on the labelling in 17(c)(i)</p>	3
Hydrogen environment	Splitting pattern of peak	Relative peak area																
(A)	(triplet)	(3)																
B	quartet	2																
C	singlet	2																
D	singlet	9																

Section B

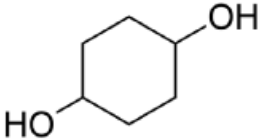
Question number	Answer	Additional guidance	Mark
16(a)(i)	<ul style="list-style-type: none"> otherwise the mass of water from the combustion cannot be measured 	Allow any indication that the measurement of water is affected Allow indication that the values of H and O obtained will be affected Ignore just reference to 'the products' Do not award (presence of water) affects the reaction of O ₂ with X Do not award water reacts with X Do not award water dissolves CO ₂	1

Question number	Answer	Additional guidance	Mark																
16(a)(ii)	<ul style="list-style-type: none"> moles of CO₂ and H₂O (1) masses of C and H (1) mass of O (1) moles of C, H and O (1) ratio (1.33:2:1), (integer ratio) and empirical formula (1) 	Example of calculation $\text{mol CO}_2 = 4.31 \div 44 = 0.097955$ $\text{mol H}_2\text{O} = 1.32 \div 18 = 0.073333$ $\text{mass of C} = 0.097955 \times 12 = 1.1755 \text{ g}$ $\text{mass of H} = 0.073333 \times 2 = 0.1467 \text{ g}$ $\text{mass of O} = 2.50 - (1.1755 + 0.1467)$ $= 1.1778 \text{ g}$ <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>C</th> <th>H</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>mol</td> <td>0.0980×1 $= 0.0980$</td> <td>0.0733×2 $= 0.147$</td> <td>$1.178/16$ $= 0.0736$</td> </tr> <tr> <td>ratio</td> <td>1.33</td> <td>2</td> <td>1</td> </tr> <tr> <td>integers</td> <td>4</td> <td>6</td> <td>3</td> </tr> </tbody> </table> C ₄ H ₆ O ₃ No TE if oxygen mass not calculated In M1 and M2 mol CO ₂ and mass of carbon scores (1) mol H ₂ O and mass of hydrogen scores (1)		C	H	O	mol	0.0980×1 $= 0.0980$	0.0733×2 $= 0.147$	$1.178/16$ $= 0.0736$	ratio	1.33	2	1	integers	4	6	3	5
	C	H	O																
mol	0.0980×1 $= 0.0980$	0.0733×2 $= 0.147$	$1.178/16$ $= 0.0736$																
ratio	1.33	2	1																
integers	4	6	3																

	<p>Allow inductive calculation</p> <ul style="list-style-type: none"> • balanced equation (1) • Formula mass (C₄H₆O₃) (1) • Product masses from equation (1) • Mass of CO₂ from 2.5 g of X (1) • Mass of H₂O from 2.5 g of X (1) 	<p>Example of inductive calculation</p> $\text{C}_4\text{H}_6\text{O}_3 + 4\text{O}_2 \rightarrow 4\text{CO}_2 + 3\text{H}_2\text{O}$ <p>Formula mass (4x12 + 6 + 3 x 16) = 102 (g)</p> <p>CO₂ = 4 x 44 = 176 (g) and H₂O = 3 x 18 = 54 (g)</p> <p>2.5 x 176 ÷ 102 = 2.5 (g)</p> <p>2.5 x 54 ÷ 102 = 1.32 (g)</p> <p>Correct answer with any correct method scores (5) Correct answer with no working scores (0)</p> <p>TE at each stage</p> <p>Ignore SF except 1 SF</p>	
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Question number	Answer	Additional guidance	Mark
16(b)(i)	<p>An answer that makes reference to the following</p> <ul style="list-style-type: none"> • two structures (2) • ^{13}C spectrum shows four different (types of) carbon atom (so molecular formula same as empirical formula) (1) • reaction with Brady's reagent indicates a carbonyl compound (1) • no reaction with Tollens' reagent indicates a ketone (group) / not an aldehyde (1) • reaction with NaHCO_3 (forming CO_2) indicates (carboxylic) acid (1) 	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>A</p> </div> <div style="text-align: center;">  <p>B</p> </div> </div> <p>Allow displayed or structural formulae or any combination of skeletal, displayed and structural Penalise incorrect horizontal -OH connectivity once Ignore names even if incorrect</p> <p>Accept X has four carbon environments Allow ^{13}C spectrum shows X has four types of carbon atom Ignore just 'X has four carbon atoms'</p> <p>Ignore just 'X is a ketone' / C=O present Do not award 'acyl'</p> <p>Accept COOH (group)</p>	6

Question number	Answer	Additional guidance	Mark
16(b)(ii)	<p>An answer that makes reference to the following</p> <ul style="list-style-type: none"> • reagents for iodoform test • result for methyl ketone • result for ethyl ketone 	<p>(1) iodine / I₂ and sodium hydroxide / NaOH / potassium hydroxide KOH</p> <p>Accept NaI / KI and NaOCl</p> <p>Allow iodine and OH⁻ / alkali</p> <p>Ignore 'iodoform test'</p> <p>(1) (pale) yellow precipitate Allow yellow solid / ppt / ppte / antiseptic smell</p> <p>(1) No change / precipitate Allow no reaction / (pale) yellow precipitate does not form</p> <p>M2 and M3 dependent on M1 or a near miss or just 'iodoform test'</p> <p>If result not linked to structure max (2)</p> <p>e.g NaOH and I₂ give yellow ppt (positive) and no reaction (negative) scores (2)</p> <p>If no reagent or an incorrect reagent given then both observation marks correct scores (1)</p> <p>Do not award use of physical methods</p>	3

Question Number	Answer	Additional Guidance	Mark
20(c)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> • a structure containing two -OH groups • correct structure 	<p>(1) Do not award an -OH group and a -COOH group Award this mark even if the structure does not contain a ring of six atoms.</p> <p>(1)</p> <div style="text-align: center;">  </div> <p>Structure may be skeletal or displayed or a mixture, as long as it is clear. Allow, for example, a displayed formula with condensed CH₂.</p> <p>Ignore connectivity of -OH</p>	(2)