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EDEXCEL A LEVEL CHEMISTRY: QUESTIONS BY TOPIC

Modern Analytical Techniques I (7)

A Level Chemistry Topic 7

4 questions · 42 marks · Mark schemes included

Pearson Edexcel A Level Chemistry (9CH0), June 2017 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any sub-topic heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
7(a) MASS SPECTROMETRY		1 question · 2 marks	3
1. Q1	A Level Paper 2 June 2025	2	4
7(b) INFRARED SPECTROSCOPY		3 questions · 40 marks	5
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QUESTIONS

4 questions · 42 marks · grouped by sub-topic



SUB-TOPIC 7(a)

MASS SPECTROMETRY

1 question in this sub-topic · 2 marks · lowest tariff first



1 This question is about mass spectrometry.

(a) Which molecule would **not** give a molecular ion peak with $m/z = 74$?

(1)

- ☐ A $\text{C}_2\text{H}_5\text{COOH}$
- ☐ B CHOCOOH
- ☐ C $\text{CH}_2(\text{OH})\text{COOH}$
- ☐ D $\text{CH}_3\text{COOCH}_3$

(b) The fragmentation pattern in a mass spectrum can be used to distinguish between structural isomers.

Which m/z peak would be present in the mass spectrum of propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, but **not** in the mass spectrum of propanone, CH_3COCH_3 ?

(1)

- ☐ A 15
- ☐ B 29
- ☐ C 43
- ☐ D 59

(Total for Question 1 = 2 marks)



SUB-TOPIC 7(b)

INFRARED SPECTROSCOPY

3 questions in this sub-topic · 40 marks · lowest tariff first



2 This question is about alcohols.

- (a) Ethanol is a fuel and can be made by either the fermentation of carbohydrates or the hydration of ethene.

How is the ethanol formed by the fermentation of carbohydrates classified?

(1)

- ☐ **A** a biofuel and non-renewable
- ☐ **B** a biofuel and renewable
- ☐ **C** a fossil fuel and non-renewable
- ☐ **D** a fossil fuel and renewable

- (b) Write the equation for the complete combustion of methanol.
State symbols are not required.

(1)

- (c) Identify, by name or formula, the reagent(s) needed to convert propan-1-ol into 1-iodopropane.

(1)

- (d) A sample of pure propan-2-ol is analysed using infrared and ^{13}C NMR spectroscopy.

- (i) Which of these sets of wavenumber ranges, in cm^{-1} , will be seen in the infrared spectrum of propan-2-ol?

(1)

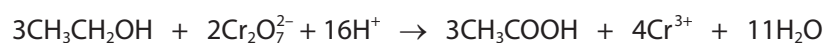
- ☐ **A** 1485 – 1365, 2962 – 2853 and 3300 – 2500
- ☐ **B** 1485 – 1365, 2962 – 2853 and 3750 – 3200
- ☐ **C** 1669 – 1645, 2962 – 2853 and 3750 – 3200
- ☐ **D** 1740 – 1720, 3300 – 2500 and 3750 – 3200

- (ii) State the number of peaks in the ^{13}C NMR spectrum of propan-2-ol.

(1)



- (e) The equation for the oxidation of ethanol by acidified dichromate(VI) ions is shown.



Deduce the half-equation for the oxidation of ethanol to ethanoic acid.
State symbols are not required.

(1)

(Total for Question 2 = 6 marks)



8 This question is about the analysis of organic compounds.

(a) **X** is an organic compound.

- (i) The accurate relative atomic masses, A_r , of the four elements that could make up **X** are shown in the table.

Element	A_r
hydrogen, H	1.0078
carbon, C	12.0000
nitrogen, N	14.0031
oxygen, O	15.9949

X gives a molecular ion peak at $m/z = 100.0522$ on its mass spectrum.

Which is the molecular formula of **X**?

(1)

- ☐ **A** C_7H_{16}
☐ **B** $C_6H_{12}O$
☐ **C** $C_6H_{14}N$
☐ **D** $C_5H_8O_2$

- (ii) The infrared spectrum of **X** contains major absorption wavenumber ranges at $3300\text{--}2500\text{ cm}^{-1}$, $1725\text{--}1700\text{ cm}^{-1}$ and $1669\text{--}1645\text{ cm}^{-1}$.

Identify the two functional groups in **X**.

(2)

- (iii) **X** has an unbranched carbon chain and does **not** exhibit geometric isomerism.

Draw the **skeletal formula** of **X**.

(1)



*(b) There are similarities and differences in the ^{13}C NMR spectra and the high resolution ^1H NMR spectra of isomeric organic compounds.

Compare the NMR spectra of propan-1-ol with those of propan-2-ol.

Include the number of peaks, relative peak areas and splitting patterns, where appropriate.

Chemical shift values are **not** required.

(6)

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(Total for Question 8 = 10 marks)



6 This question is about the analysis of an unknown carboxylic acid **X** by three students.

The students analyse the mass spectrum of **X** and find that it has a molecular ion peak at $m/z = 116$.

The three students each propose a different structural formula for compound **X**.

Structure 1 $\text{HOOCCH}=\text{CHCOOH}$

Structure 2 $\text{HOCH}_2\text{CH}=\text{CHCH}_2\text{COOH}$

Structure 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$

(a) The students are given the infrared spectrum of **X**.

- (i) State **two** wavenumber ranges of the infrared absorptions providing evidence that compound **X** is a carboxylic acid. Include the bonds responsible.

(2)

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- (ii) One of the students suggests that this infrared spectrum and the data in the Data Booklet **alone** could be used to identify which of the three proposed structures is **X**.

Show that this student's suggestion is correct. Include relevant infrared data in your answer.

(3)

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(b) The students decide to carry out an acid-base titration to obtain further information about compound **X**.

Each student uses solid sodium hydroxide, NaOH, to prepare a solution of concentration $0.140 \text{ mol dm}^{-3}$.

Calculate the mass, in grams, of solid sodium hydroxide that each student should weigh out to prepare 250.0 cm^3 of a $0.140 \text{ mol dm}^{-3}$ solution.

(2)



- (c) Each of the students makes up 250.0 cm^3 of 0.140 mol dm^{-3} sodium hydroxide solution in a volumetric flask and titrates this solution with the same solution of **X** of known concentration.

Student A

- correctly prepares the 0.140 mol dm^{-3} sodium hydroxide solution and pipettes a volume of 10.0 cm^3 of the solution into a conical flask
- fills a burette with the solution of **X** and carries out a titration
- repeats the procedure until obtaining concordant results
- obtains a mean titre of 10.20 cm^3 .

Student B

- dissolves the sodium hydroxide in distilled water and transfers the solution to a volumetric flask
- adds more distilled water to the volumetric flask and mixes the solution
- notices that the volumetric flask has been filled with distilled water several cm^3 beyond the graduation mark
- realises the mistake, removes the extra solution and discards it
- pipettes 10.0 cm^3 of the sodium hydroxide solution into a conical flask and titrates this with the solution of **X**.

Student C

- correctly prepares the 0.140 mol dm^{-3} sodium hydroxide solution
- washes a conical flask thoroughly with distilled water and pipettes 10.0 cm^3 of the sodium hydroxide solution into the wet conical flask
- titrates the contents of the conical flask with the solution of **X**.

- (i) Explain how, if at all, Student **B**'s mistake affects the value of the titre.

(2)

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- (ii) Explain how, if at all, Student **C**'s use of a wet conical flask affects the value of the titre.

(2)

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(iii) Student **A** uses three pieces of apparatus to measure volumes in this experiment.

- The burette has an uncertainty of $\pm 0.05 \text{ cm}^3$ for each volume reading
- The volumetric flask has an uncertainty of $\pm 0.30 \text{ cm}^3$ for the volume
- The pipette has an uncertainty of $\pm 0.04 \text{ cm}^3$ for the volume

Show by calculation which volume measurement has the lowest percentage uncertainty.

(3)



- (d) Student **A** calculates the correct value for the molar mass of compound **X**, using the mean titre of 10.20 cm³. The results indicate that **X** has **structure 1**.

Structure 1 HOOCCH=CHCOOH

Structure 2 HOCH₂CH=CHCH₂COOH

Structure 3 CH₃CH₂CH₂CH₂CH₂COOH

- (i) Write the equation for the reaction between **structure 1** and sodium hydroxide solution. State symbols are not required.

(2)

- (ii) Deduce the value that would have been obtained for the mean titre if the structural formula of **X** had been **structure 2**. Justify your answer.

(2)

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- (e) The students could have identified the three structures using chemical tests.

Complete the table to show whether or not the suggested structures react with bromine water and when heated with acidified potassium dichromate(VI).

Use a tick (✓) if a reaction occurs.

Use a cross (✗) if no reaction occurs.

(2)

Structure	Test with bromine water	Test with acidified potassium dichromate(VI)
HOOCCH=CHCOOH		
HOCH ₂ CH=CHCH ₂ COOH		
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ COOH		



(f) The structure $\text{HOOCCH}=\text{CHCOOH}$ has two stereoisomers.

(i) Draw the structures of these stereoisomers.

(2)

***E*-isomer**

***Z*-isomer**

(ii) State why $\text{HOOCCH}=\text{CHCOOH}$ has *E/Z* isomers.

(2)

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(Total for Question 6 = 24 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Answer	Mark
1(a)	The only correct answer is C ($\text{CH}_2(\text{OH})\text{COOH}$) <i>A is not correct because propanoic acid has a relative molecular mass of 74 and so would have a molecular ion peak with $m/z = 74$</i> <i>B is not correct because oxoethanoic acid has a relative molecular mass of 74 and so would have a molecular ion peak with $m/z = 74$</i> <i>D is not correct because methyl ethanoate has a relative molecular mass of 74 and so would have a molecular ion peak with $m/z = 74$</i>	(1)

Question Number	Answer	Mark
1(b)	The only correct answer is B (29) <i>A is not correct because both propanal and propanone could produce a CH_3^+ fragment with $m/z = 15$</i> <i>C is not correct because propanal could produce the fragment $[\text{CH}_2\text{CHO}^+]$ and propanone could produce the fragment $[\text{CH}_3\text{CO}^+]$ which both have $m/z = 43$</i> <i>D is not correct because both propanal and propanone have this $(M+1)^+$ peak which is not a fragment ion</i>	(1)

(Total for Question 1 = 2 marks)



Question number	Answer	Mark
2(a)	The only correct answer is B (a biofuel and renewable) <i>A is incorrect because ethanol is renewable using the fermentation process</i> <i>C is incorrect because ethanol is made from plants and is renewable using the fermentation process</i> <i>D is incorrect because ethanol is made from plants</i>	(1)

Question Number	Answer	Additional Guidance	Mark
2(b)	balanced equation	<u>Example of equation</u> $\text{CH}_3\text{OH} + 1\frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ or $2\text{CH}_3\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 4\text{H}_2\text{O}$ Allow fractions e.g. $3/2 \text{ O}_2$ Allow CH_4O for methanol Ignore state symbols	(1)



Question Number	Answer	Additional Guidance	Mark
2(c)	(red) phosphorus and iodine / P or P₄ and I₂ or phosphorus(III) iodide / PI₃	Allow name or formula but if both are given both must be correct. Allow potassium or sodium iodide / KI or NaI and phosphoric(V) acid / H₃PO₄ Allow white phosphorus and iodine Allow hydrogen iodide / HI Allow red phosphorus and PI₃ Ignore solvent Do not award phosphorus(V) iodide / PI₅ Do not award KI and /or H₂SO₄	(1)

Question number	Answer	Mark
2(d)(i)	The only correct answer is B (1485 – 1365, 2962 – 2853 and 3750 – 3200 cm⁻¹) <i>A is incorrect because 3300 – 2500 cm⁻¹ is for an O-H in a carboxylic acid</i> <i>C is incorrect because 1669 – 1645 cm⁻¹ for C=C in an alkene</i> <i>D is incorrect because 1740 – 1720 cm⁻¹ is for C-O in an aldehyde and 3300 – 2500 cm⁻¹ is for an O-H in a carboxylic acid</i>	(1)



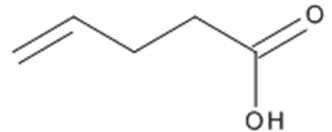
Question Number	Answer	Additional Guidance	Mark
2(d)(ii)	2 / two		(1)

Question Number	Answer	Additional Guidance	Mark
2(e)	half-equation	<u>Example of half-equation</u> $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^-$ Allow multiples Allow -4e^- on left hand side of equation Ignore missing charge on electron Ignore state symbols	(1)

(Total for Question 2 = 6 marks)

Question number	Answer	Mark
8(a)(i)	The only correct answer is D (C₅H₈O₂) <i>A is incorrect because C₇H₁₆ has a molecular ion m / z = 100.1248</i> <i>B is incorrect because C₆H₁₂O has a molecular ion m / z = 100.0885</i> <i>C is incorrect because C₆H₁₄N has a molecular ion m / z = 100.1123</i>	(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	- alkene / C=C (1) - carboxylic acid / COOH (1)	The functional groups can be in any order Ignore just 'double bond' Ignore just C=O and OH	(2)

Question Number	Answer	Additional Guidance	Mark
8(a)(iii)	skeletal formula of X	Example of skeletal formula  Ignore bond lengths and bond angles	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark												
8(b)*	This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning.	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points														
6	4														
5-4	3														
3-2	2														
1	1														
0	0														

		Number of marks awarded for structure of answer and sustained line of reasoning	
	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2	
	Answer is partially structured with some linkages and lines of reasoning.	1	
	Answer has no linkages between points and is unstructured.	0	
Comment: Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning			In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. General points to note If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). e.g. Mention of splitting on the ^{13}C spectra Deduct 1 reasoning mark if the similarity in IP1 has not been explicitly mentioned

	Indicative content • IP1 - Similarity both ^1H NMR spectra have a peak (which is a singlet with relative peak area 1) for OH • IP2 - ^{13}C spectra 3 peaks for propan-1-ol and 2 peaks for propan-2-ol • IP3 - ^1H spectra number of peaks 4 peaks for propan-1-ol and 3 peaks for propan-2-ol • IP4 - ^1H spectra relative peak areas (relative) peak areas 3 : 2 : 2 : 1 for propan-1-ol, 6 : 1 : 1 for propan-2-ol • IP5 - ^1H splitting pattern for propan-1-ol 2 triplets, 1 sextet / split into 6 and 1 singlet • IP6 - ^1H splitting pattern for propan-2-ol 1 doublet, 1 septet / split into 7 and 1 singlet	All IP can be shown on clearly labelled diagrams of structures and/or spectra Allow carbon environments for peaks Ignore any reference to peak areas Allow 3 : 2 : 2 and 6 : 1 if peak areas for OH given in similarity Allow ratios in any order e.g. 1 : 2 : 2 : 3 Allow hextet for sextet Ignore missing singlet if this has been given in similarity Allow heptet for septet Ignore missing singlet if this has been given in similarity	
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(Total for Question 8 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(a)(i)	An answer that makes reference to the following points: 3300 — 2500 (cm^{-1}) and O-H (bond) (1) 1725 — 1700 (cm^{-1}) and C=O (bond) (1)	Allow any value(s) within the range 3300 — 2500 (cm^{-1}) Allow -OH Allow any value(s) within the range 1725 — 1700 (cm^{-1}) Allow 1320 – 1210 (cm^{-1}) and C-O	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(a)(ii)	An answer that makes reference to the following points: - structures 1 and 2 will have an absorption at Either C=C at 1669 — 1645 (cm^{-1}) or C—H in an alkene at 3095 — 3010 (cm^{-1}) (1) - only structure 2 will have an absorption due to the presence of an alcohol / O—H at 3750 — 3200 (cm^{-1}) (1) - structure 3 will have none of these absorptions / will not show C=C absorption / C-H absorption for an alkene (1)	Reject C=C at 3010 (cm^{-1})	(3)



Question Number	Acceptable Answers	Additional Guidance	Mark
6(b)	- calculation of moles of NaOH (1) - calculation of mass of NaOH (1)	<u>Example of calculation:</u> (moles NaOH = $0.140 \times \frac{250}{1000}$) = 0.035(0) (mol) = $40(.0) \times 0.035(0) = 1.4(0)$ (g) Correct answer with or without working scores 2 marks Allow TE for M2 on moles of NaOH Alternative route, allow M1 for conversion of concentration to 5.6 g dm^{-3} Ignore SF	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(i)	An explanation that makes reference to the following points: (because the) sodium hydroxide has been diluted (1) (the titre will be) smaller (1)	Allow Fewer moles of sodium hydroxide present / some sodium hydroxide will have been removed M2 dependent on M1	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) (1) M2 because the (number of) moles of sodium hydroxide is unaffected (1)	M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow amount / mass of sodium hydroxide is unaffected	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)(iii)	- calculation of percentage uncertainty in burette volume (1) - calculation of percentage uncertainty in volumetric flask volume and in pipette volume (1) - identification of volume with the lowest percentage uncertainty (1)	<u>Example of calculation:</u> $\frac{2 \times (\pm)0.05}{10.20} \times 100\% = (\pm)0.980392156\%$ $\frac{(\pm)0.30}{250.0} \times 100\% = (\pm)0.12\%$ and $\frac{(\pm)0.040}{10.0} \times 100\% = (\pm)0.4\%$ Volumetric flask has the lowest uncertainty Allow TE for identification in M3 Allow ANY number of SF in answer, from 1 SF up to calculator value	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(d)(i)	- left-hand side of equation correct (1) - right-hand side of equation correct (1)	<u>Example of equation</u> $\text{HOOCCH}=\text{CHCOOH} + 2\text{NaOH} \rightarrow \text{NaOOCCH}=\text{CHCOONa} + 2\text{H}_2\text{O}$ ALLOW use of molecular formulae or ionic equation: $\text{C}_4\text{H}_4\text{O}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{C}_4\text{H}_2\text{O}_4 + 2\text{H}_2\text{O}$ $\text{HOOCCH}=\text{CHCOOH} + 2\text{OH}^- (+ 2\text{Na}^+) \rightarrow \text{OOCCH}=\text{CHCOO}^- + 2\text{H}_2\text{O} (+ 2\text{Na}^+)$ ALLOW Multiples Correct charges Do not award if O–Na covalent bond drawn IGNORE State symbols, even if incorrect	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(d)(ii)	An answer that makes reference to the following points: (New mean titre) = 20.4(0) (cm³) / double (the original value) (1) - For structure 2, mole ratio / reacting ratio is 1:1 (with NaOH) (1)	Mark M1 and M2 independently Allow structure 2 has 1 COOH / 1 acid group	(2)



Question Number	Acceptable Answers			Additional Guidance	Mark
6(e)				3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	(2)
	Structure	Test with Br ₂ water	Test with acidified K ₂ Cr ₂ O ₇		
	HOOCCH=CHCOOH	✓	x		
	HOCH ₂ CH=CHCH ₂ COOH	✓	✓		
	CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ COOH	x	x		
	Left hand column correct (1) Right hand column correct (1)				



Question Number	Acceptable Answers	Additional Guidance	Mark
6(f)(i)	<i>E</i>-isomer: $\begin{array}{ccc} \text{HOOC} & & \text{H} \\ & \diagdown \quad \diagup & \\ & \text{C} = \text{C} & \\ & \diagup \quad \diagdown & \\ \text{H} & & \text{COOH} \end{array}$ <i>Z</i>-isomer: $\begin{array}{ccc} \text{HOOC} & & \text{COOH} \\ & \diagdown \quad \diagup & \\ & \text{C} = \text{C} & \\ & \diagup \quad \diagdown & \\ \text{H} & & \text{H} \end{array}$	ALLOW skeletal or displayed structures ALLOW $\text{-CO}_2\text{H}$ IGNORE Connectivity to the -COOH group IGNORE bond angles Award one mark if correct structures are drawn, but <i>E</i> - and <i>Z</i> -isomers labelled the wrong way round Award 1 mark if incorrect molecule used but <i>E</i> - and <i>Z</i> - isomers are correct	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(f)(ii)	An answer that makes reference to the following points: - restricted / limited rotation (about the $\text{C}=\text{C}$ double bond) - each carbon atom in the double bond is attached to (two) different atoms / different groups (of atoms) / to a H (atom) and a COOH group	Allow "no rotation" Do not award the carbons are attached to 2 "different molecules" Mark points M1 and M2 independently	(2)

(Total for Question 6 = 24 marks)

