OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced GCE

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

Mark Scheme for June 2012

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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.

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Annotations

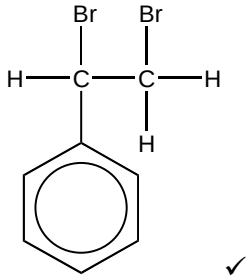
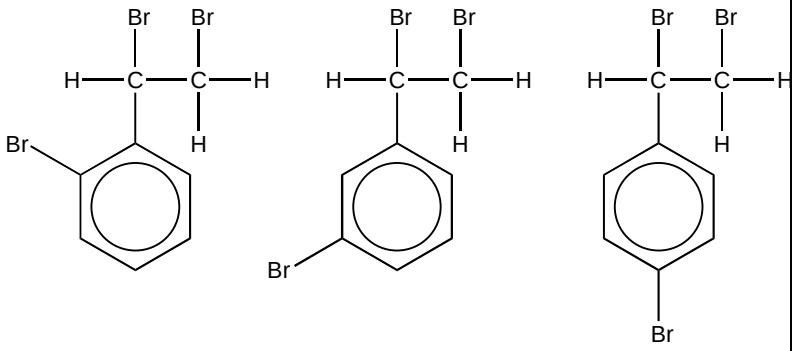
Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response

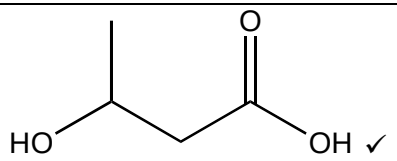
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording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

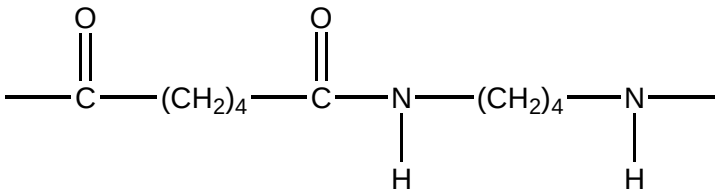
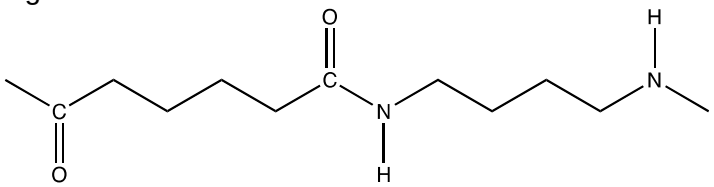
The following questions should be annotated with ticks, etc. to show where marks have been awarded in the body of the text:

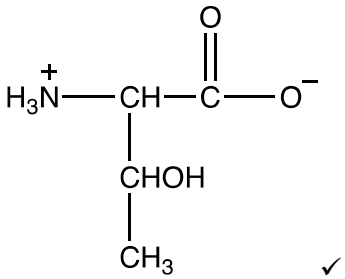
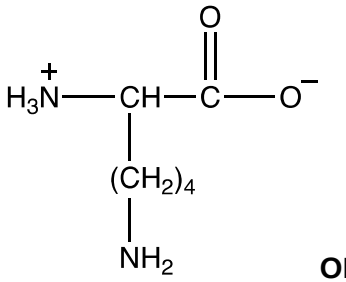
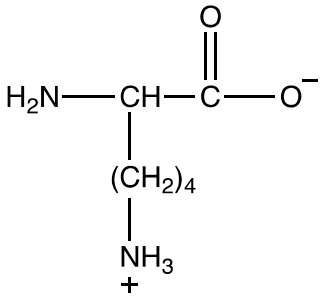
Q1(a), Q3(c)(iii), **Q4(a), Q4(d)(i)**, **Q5(b)**.

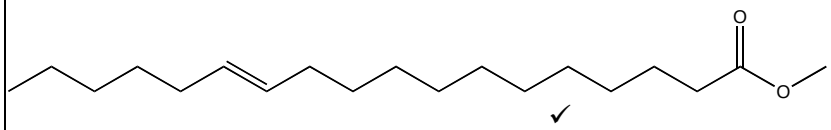
Question			Answer	Marks	Guidance
1	(a)		In benzene, electrons **OR** π-bond(s) are **delocalised** ✓ **QWC** requires delocalised/delocalized **spelled correctly** and used in correct context In alkenes, TT-electrons are **OR** TT-bond is **AND** localised **OR** between two carbons ✓ benzene has a lower electron density **OR** alkene/C=C has a higher electron density ✓ *Comparison* ***essential*** benzene polarises bromine / Br_2 **LESS** **OR** benzene attracts bromine / Br_2 **LESS** **OR** benzene induces a **weaker** dipole in bromine / Br_2 ✓	4	***ANNOTATIONS MUST BE USED*** **ALLOW** diagram with (π-bond) electrons **AND** delocalised **labelled** **IGNORE** benzene has delocalised structure or ring **ALLOW** diagram with π-bond labelled **ALLOW** pi bond for π-bond **π**-bond **OR π-**electrons ***essential*** *for this mark* **IGNORE** charge density **DO NOT ALLOW** electronegativity **ALLOW** Br–Br for Br_2 **ALLOW** electrophile for Br_2 **ALLOW** benzene does **NOT** polarise bromine / Br_2 **OR** alkene/C=C polarises Br_2 **ALLOW** benzene does **NOT** attract bromine / Br_2 **OR** alkene/C=C attracts Br_2 **ALLOW** benzene does **NOT** induce dipole in bromine / Br_2 **OR** alkene/C=C induces dipole in Br_2

Question			Answer	Marks	Guidance
1	(b)	(i)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous
		(ii)	6 ✓	1	**NO ECF from (i)**
		(iii)	Two of the three structures below with 1 mark for each correct structure ✓✓ 	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous Structures must clearly show position of Br on benzene ring in relation to side chain **ALLOW ECF** from **(i)** if **BOTH** Br atoms on same carbon on side chain **DO NOT ALLOW ECF** from **(i)** if **EITHER** bromine has been substituted onto the benzene ring
		(iv)	**reaction 1**: electrophilic addition ✓ **reaction 2**: electrophilic substitution ✓	2	**ALLOW** electrophile addition **ALLOW** electrophile substitution **ALLOW** other phonetic spellings for electrophilic, e.g. electrophylic, etc.
			Total	**10**	

Question			Answer	Marks	Guidance
2	(a)	(i)	photodegradable **OR** light/sunlight/UV ✓	1	**IGNORE** IR/heat **IGNORE** bacteria **DO NOT ALLOW** burn/combustion
		(ii)	 ✓	1	**DO NOT ALLOW** structure with any C shown (especially as part of C=O) **DO NOT ALLOW** OH—
	(b)	(i)	ammonia/NH_3 **AND** ethanol **OR** ethanolic ammonia ✓	1	**ALLOW** ammonia in a sealed tube **IGNORE** heat **ALLOW** dilute ethanolic ammonia /NH_3 **DO NOT ALLOW** any reference to water or hydroxide ions, e.g. **DO NOT ALLOW** dilute ethanolic NH_3(**aq**) e.g. **DO NOT ALLOW** ethanolic NH_3 + NaOH
		(ii)	**Nitrogen** electron pair/lone pair accepts a proton/H^+ ✓ *Requires position of electron pair on N* $Cl^-H_3N^+(CH_2)_4N^+H_3\,Cl^-$ **OR** $ClH_3N(CH_2)_4NH_3Cl$ ✓	2	**DO NOT ALLOW** Nitrogen/N lone pair accepts hydrogen *proton/H^+ required* **ALLOW nitrogen** donates an electron pair **IGNORE** NH_2 group donates electron pair **ALLOW** + charge (if shown) on N or H of NH_3 e.g. $Cl^-H_3N^+(CH_2)_4NH_3^+Cl^-$ **DO NOT ALLOW** just $H_3N^+(CH_2)_4NH_3^+$ i.e. **2 x** Cl^- **MUST** be included

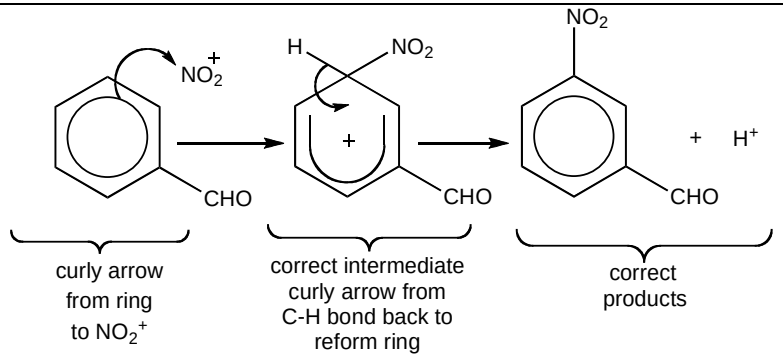
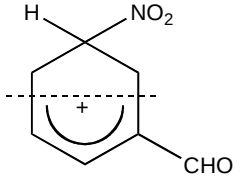
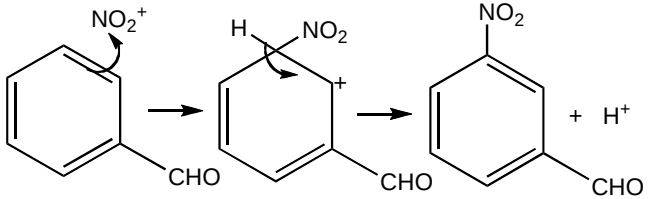
Question			Answer	Marks	Guidance
2		(iii)	1 mark for amide/peptide link correctly displayed within an attempted repeat unit ✓ 1 mark for rest of structure correct including side links ✓ 	2	Minimum requirement is each end of a displayed amide group attached to a carbon atom (could be skeletal) Brackets **not** required **IF** more than one repeat unit has been drawn a single repeat unit **MUST** be identified by brackets or clear label **DO NOT ALLOW 2nd** mark if amide/peptide link wrong *1st mark requires amide group fully displayed* *For 2nd mark, **ALLOW** –CONH– in correct structure* **ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous e.g. 

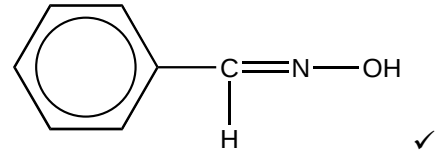
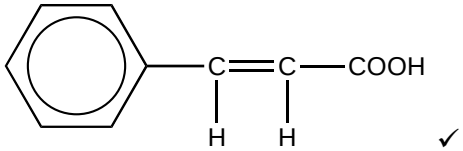
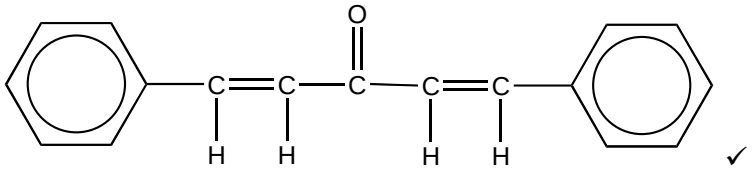
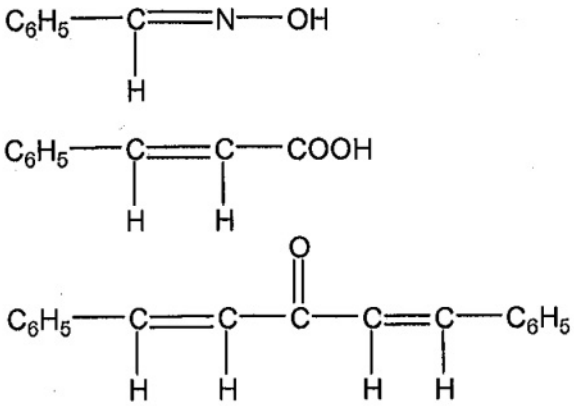
Question			Answer	Marks	Guidance
2	(c)	(i)	One mark for each correct structure  ✓  **OR**  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous **ALLOW** COO^- '–' charge must be on O of COO^- but **ALLOW** + sign shown as $^+NH_3$ **OR** NH_3^+ **BUT** only one NH_2 can be protonated in zwitterion
		(ii)	Zwitterion at pH 9.60/higher pH has **one** NH_2 group **OR** Zwitterion **OR** amino acid at pH 9.60/higher pH has a side chain with an NH_2 group ✓ **Note:** **ASSUME** that 'it' refers to zwitterion	1	**ALLOW** amino acid at 9.60/higher pH has **two** NH_2 groups **ALLOW** amino acid at 9.60/higher pH has more NH_2 groups **ALLOW** amine **OR** amino for NH_2 **IGNORE** CHOH slightly acidic
			Total	**10**	

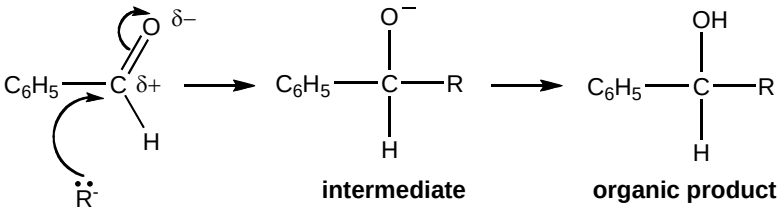
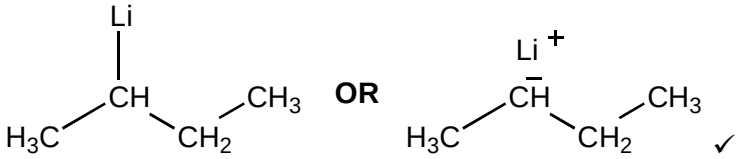
Question			Answer	Marks	Guidance
3	(a)	(i)	 ✓ *cis*-isomer has Hs on same side **OR** *cis*-isomer has branches on same side **OR** *cis*-isomer has same groups on same side **OR** *cis*-isomer has lowest priority groups on same side **OR** *cis*-isomer has highest priority groups on same side ✓	2	**ALLOW** *trans*-isomer has Hs on opposite sides **OR** *trans*-isomer has branches on opposite sides **OR** *trans*-isomer has same groups on opposite sides **DO NOT ALLOW** 'similar groups' for 'same groups' **OR** *trans*-isomer has lowest priority groups on opposite sides **OR** *trans*-isomer has highest priority groups on opposite sides ✓ For explanation, **ALLOW** a clear diagram, *ie*:  *cis* **ALLOW** response in terms of packing, e.g. molecules/chains of *trans*-isomer pack close together **OR** molecules/chains of *cis*-isomer do **not** pack closely together **DO NOT ALLOW** 'carbon atoms' for 'molecules/chains'
		(ii)	heart disease**/**strokes ✓	1	**ALLOW** any named heart/circulatory complaint e.g. atheroma, atherosclerosis **ALLOW** increase in **bad** cholesterol/LDL **ALLOW** high in LDLs **ALLOW** fat lining arteries **ALLOW** high blood pressure **ALLOW** hypertension **IGNORE** reference to HDLs and cholesterol on its own

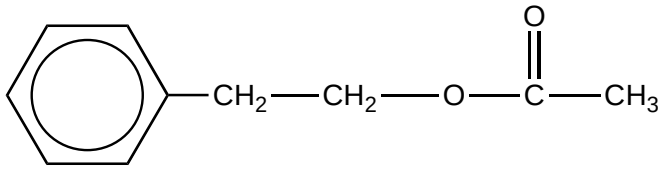
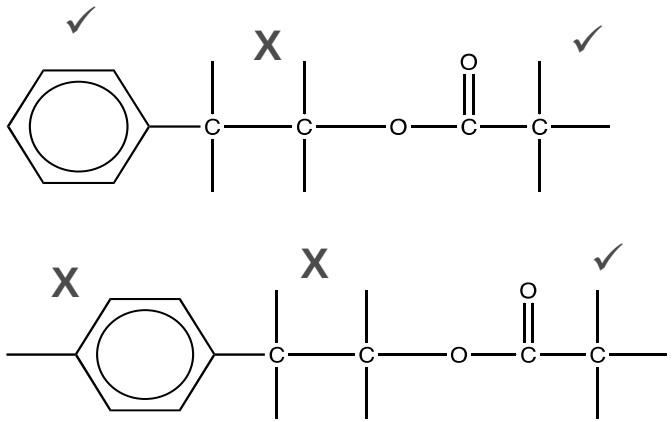
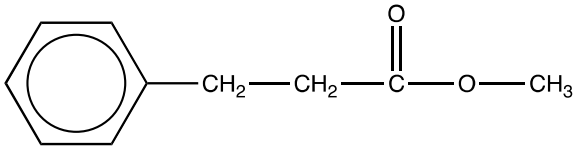
Question			Answer	Marks	Guidance
3	(b)	(i)	27	1	
		(ii)	8	1	
	(c)	(i)	alcohol ✓ ester ✓	2	**IGNORE** OH **OR** hydroxyl **OR** hydroxy **DO NOT ALLOW** phenol **OR** hydroxide **IGNORE** COOR **IF** there is a list with more than two responses, mark wrong responses first, e.g. alcohol, ketone **X**, ether **X** zero marks alcohol ✓, ester, methyl **X** 1 mark ester, hydroxide **X**, ketone **X** zero marks ester ✓, hydroxyl **I**, ketone **X** 1 mark
		(ii)	ensures correct chirality ✓	1	**ALLOW** enantiomer for optical isomer **ALLOW** produces only one **optical** isomer **ALLOW** stops need/cost/difficulty of separating **optical** isomers **ALLOW** stops formation of the **optical** isomer which may have (harmful) side effects **DO NOT ALLOW** lower doses/dosage needed **DO NOT ALLOW** forms one stereoisomer (could be *E*/*Z*) **DO NOT ALLOW** stereoselectivity

Question			Answer	Marks	Guidance
3		(iii)	**1st step** *reagent*: $NaBH_4$ ✓ *functional groups*: **aldehyde** forms an **alcohol** ✓ *names required* **2nd step** Marks **ONLY** available from correct **hydroxycarboxylic acid** formed in 1st step *reagent*: Acid **OR** H^+ (catalyst) ✓ *functional groups*: **alcohol** and **carboxylic acid / carboxyl group** form an **ester** ✓ *names required*	4	***ANNOTATIONS MUST BE USED*** **ALLOW** H_2/Ni (catalyst) **DO NOT ALLOW** $LiAlH_4$ (*because $LiAlH_4$ reduces COOH*) **IGNORE** type of reaction or conditions **IGNORE** CHO **OR** OH **IGNORE** carbonyl **OR** hydroxyl **OR** hydroxy **DO NOT ALLOW** phenol **OR** hydroxide **ALLOW** named acid/correct formula **IGNORE** dilute/concentrated **IGNORE** OH, COOH, COO, **IGNORE** hydroxyl **OR** hydroxy **DO NOT ALLOW** phenol **OR** hydroxide
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)		 **M1** ✓ **M2** ✓ **M3** ✓ **M4** ✓ --- **Note**: **ALLOW M1**, **M2 AND M3** for benzene **OR ANY** substituted benzene compound For **M4**, credit **ONLY** the **correct** products --- $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$ ✓ $H^+ + HSO_4^- \longrightarrow H_2SO_4$ ✓ **OR** $HNO_3 + 2H_2SO_4 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ ✓ $H^+ + HSO_4^- \longrightarrow H_2SO_4$ ✓ **OR** $HNO_3 + H_2SO_4 \longrightarrow H_2NO_3^+ + HSO_4^-$ **AND** $H_2NO_3^+ \longrightarrow NO_2^+ + H_2O$ ✓ $H^+ + HSO_4^- \longrightarrow H_2SO_4$ ✓	6	***ANNOTATIONS MUST BE USED*** --- **Mark 1 (M1)** **ALLOW** curly arrow from the ring **OR** from within the ring --- **Mark 2 (M2)** – intermediate showing delocalisation over less than 6 carbons with the correct orientation **BUT DO NOT ALLOW** intermediate with π system less than halfway up:  --- **Mark 3 (M3)** curly arrow from C–H bond reforming π-delocalised ring in benzene **ALLOW** Kekulé mechanism:  **ALLOW** double bonds shown in other Kekulé arrangement --- **Mark 4 (M4)** **BOTH** correct products: **3**-nitrobenzaldehyde **AND** H^+

Question			Answer	Marks	Guidance
4	(b)		$2\ C_6H_5CHO + KOH \longrightarrow C_6H_5CH_2OH + C_6H_5COOK$ **OR** $2\ C_6H_5CHO + OH^- \longrightarrow C_6H_5CH_2OH + C_6H_5COO^-$ 1 mark for $C_6H_5CH_2OH$ ✓ 1 mark for C_6H_5COOK **OR** C_6H_5COOH **OR** $C_6H_5COO^-$ ✓ 1 mark for complete fully correct balanced equation (i.e. as above) ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous **ALLOW** use of NaOH instead of KOH throughout, i.e. $2\ C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COONa$ **ALLOW** $C_6H_5COO^-K^+$
	(c)		 ✓  ✓  ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous e.g. **ALLOW** 

Question			Answer	Marks	Guidance
4	(d)	(i)	 **intermediate** **organic product** 1 mark for curly arrow from R^- to C of C=O (lone pair not necessary) ✓ 1 mark for correct dipoles on C=O **AND** curly arrow from double bond to $O^{\delta-}$ ✓ 1 mark for correct intermediate with – charge on O ✓ 1 mark for correct product ✓	4	***ANNOTATIONS MUST BE USED*** **IGNORE** connectivity on OH of product Curly arrow **MUST** start from – sign of R^- **OR** from lone pair on R^- lone pair **does not need** to be shown on R^- **IGNORE** any curly arrows shown for **stage 2** i.e. in intermediate
		(ii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous **IGNORE** C_4H_9Li **OR** $C_4H_9^-Li^-$
			Total	**17**	

Question			Answer	Marks	Guidance
5	(a)	(i)	(number of esters) from number of peaks/retention times **AND** (proportions) from (relative) peak areas ✓	1	**BOTH** points for 1 mark **ALLOW** peak heights **OR** sizes of peaks
		(ii)	(Some esters may have) same retention time ✓	1	**ALLOW** (very) similar retention times **ALLOW** some esters come out at same time
	(b)		**Ester structure 3 marks**  ✓✓✓ **STICKS** IF there are sticks are shown in CH_2CH_2 **OR** in CH_3 **DO NOT AWARD** when first seen **DO NOT ALLOW** sticks on the benzene ring, *Sticks on benzene ring **must** be interpreted as methyl groups* e.g. 	3	***ANNOTATIONS MUST BE USED*** **----------** **ALLOW** correct structural **OR** displayed **OR** skeletal formula **ALLOW** combination of formulae as long as unambiguous **NO ECF** for structure **----------** **IF** the structure is **NOT** fully correct, award the following marks: **IF ESTER** shown **AND** contains **ONE** of the following: C_6H_5 **OR** $CH_3C{=}O$ **OR** CH_2CH_2 1 mark ✓ **IF ESTER** shown **AND** contains **TWO** of the following: C_6H_5 **OR** $CH_3C{=}O$ **OR** CH_2CH_2 2 marks ✓✓ **IF ESTER** contains **C_6H_5 AND** CH_2CH_2 **BUT** ester link is reversed 2 marks ✓✓  **DO NOT ALLOW** CH_2CH_2 with H on any adjacent Cs e.g. **DO NOT ALLOW** $CH_2CH_2CH_3$, $CH_2CH_2CH_2$, etc. **IGNORE** any name

Question	Answer	Marks	Guidance
	Mass spectrum 164 linked directly to molecular formula of $C_{10}H_{12}O_2$ **OR** an ester structure with formula $C_{10}H_{12}O_2$ ✓ *This direct link could be seen anywhere in the response* e.g. 164 is $C_{10}H_{12}O_2$ e.g. $C_{10}H_{12}O_2$ = 120 + 12 + 32 = 164 e.g. (164 – 44/COO) = 120; 120 = C_9H_{12} --- **NMR analysis** **QWC** *Triplet must be spelled correctly and used in correct context* Triplet at 2.8 ppm shows an adjacent CH_2 **AND** Triplet at 4.4 ppm shows an adjacent CH_2 ✓ Peak at 2.2 shows C**H_3**–C=O **OR** Peak at 2.2 shows HC–C=O **AND 3** Hs of this type **OR** Peak at 2.2 shows HC–C=O **AND** adjacent to (C with) no Hs✓ Peak at 7.3 shows **5 aromatic Hs OR** shows C_6**H_5** ✓ *5Hs required* Peak at 2.8 shows C_6H_5–C**H OR** C_6H_5–C**H_2** ✓ *Just require C_6H_5–CH as testing environment here* Peak at 4.4 due to **H**C–O **OR** **H_2**C–O ✓ *Just require HC–O as testing environment here*	1 --- 5	***Check back for any responses added to spectrum*** ***Credit responses throughout provided that it is clear which peaks are being referred to*** --- **ALLOW** tolerance on δ values: ± 0.2 ppm Throughout**, ALLOW** for H: proton **OR** H^+ For adjacent CH_2, **ALLOW** (C) adjacent to 2 Hs **ALLOW** There are 2 triplets **AND** triplet shows an adjacent CH_2 For peak at (δ =) 2.2 **ALLOW** singlet **OR** peak labelled 3 For peak at (δ =) 7.3 **ALLOW** peak labelled 5 **OR** multiplet **OR** quintet **OR** hextet **OR** heptet For peak at (δ =) 2.8 **ALLOW** triplet at 2.8 For peak at (δ =) 4.4 **ALLOW** triplet at 4.4
	Total	**11**	

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