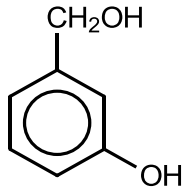
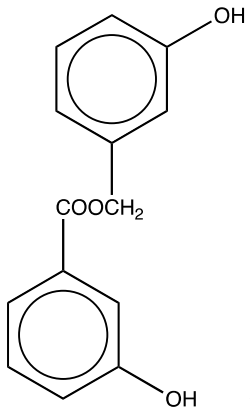
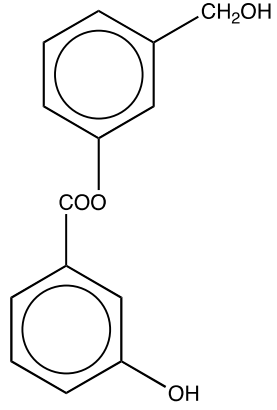
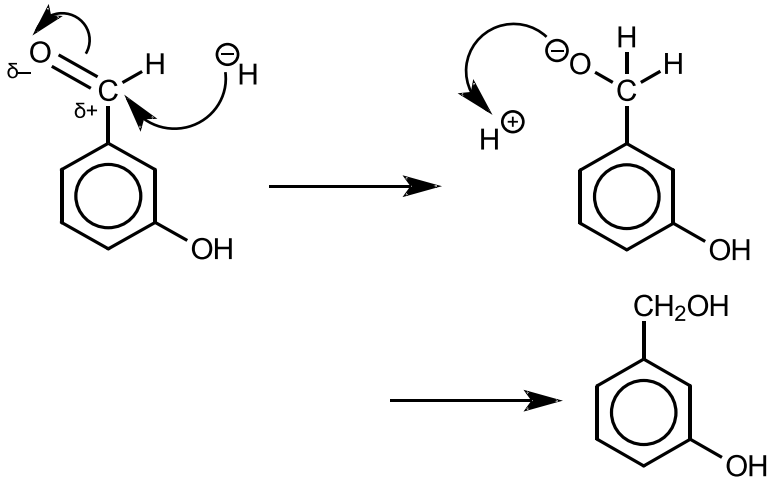
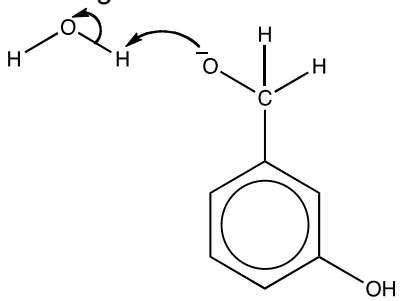
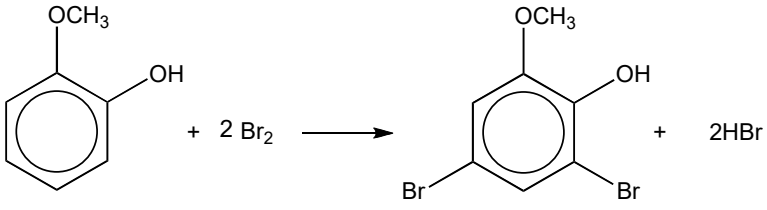
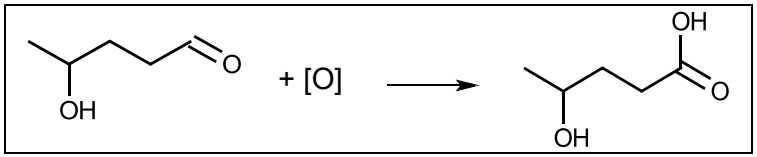
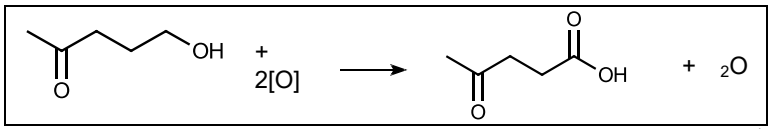
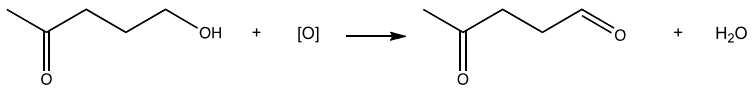
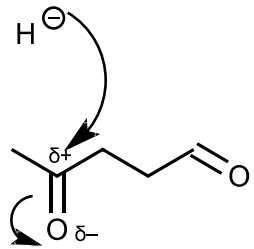
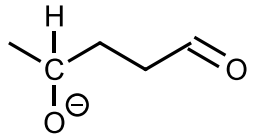
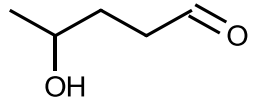
Question			Answer	Mark	Guidance
1	(a)		(Relative) solubility (in stationary phase) ✓	1	**ALLOW** how well the compound dissolves **IGNORE** retention time **AND** partition **DO NOT ALLOW** adsorption **OR** absorption
	(b)	(i)	Compound **B** **AND** M^+/molecular ion peak (at *m*/*z*) = 124 ✓	1	**ALLOW** Mr = 124 **IGNORE** compound B because *m*/*z* = 124 **ALLOW** $C_7H_8O_2^+$ = 124 **OR** $C_7H_8O_2$ = 124 **ALLOW** peak at (m/z =) 109 due to $HOC_6H_4O^+$ **ALLOW** peak at (m/z =) 109 due to loss of CH_3 **IGNORE** reference to other peaks in the spectrum
		(ii)	Compound (B) is less soluble in the stationary phase/ liquid	1	**ORA** Answer refers to the first compound to emerge from the column **ALLOW** compound (B) is more soluble in mobile phase/gas **ALLOW** compound interacts less with stationary phase/liquid **OR** compound interacts more with mobile phase/gas **IGNORE** compound adsorbs less **IGNORE** compound is not very soluble (comparison needed) **IGNORE** volatility **OR** reactivity

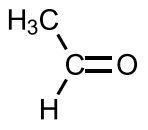
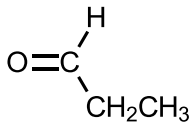
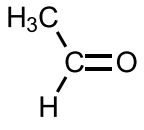
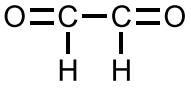
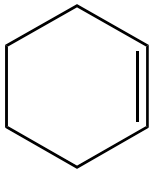
Question			Answer	Mark	Guidance
	(c)	(i)	reagent = $K_2Cr_2O_7$ **AND** H_2SO_4 ✓	3	**ALLOW** acidified dichromate **ALLOW** H^+/any acid **IGNORE** concentration of acid **ALLOW** $Na_2Cr_2O_7$ /$Cr_2O_7^{2-}$ /(potassium **OR** sodium) dichromate((VI)) **ALLOW** acidified MnO_4^- **ALLOW** Tollens' reagent/ammoniacal silver nitrate **IGNORE** conditions
			compound C =  ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW ECF** from incorrect **compound C** Check positions of OH groups **ALLOW** esterification of phenol group
			ester =  ✓		

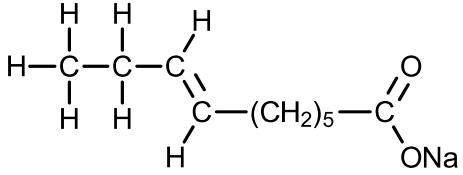
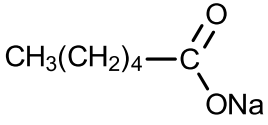
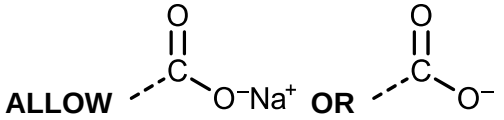
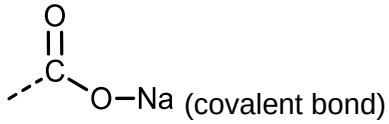
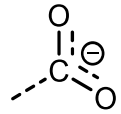
Question	Answer	Mark	Guidance
(ii)	curly arrow from H^- to $C^{\delta+}$ ✓ dipole **AND** curly arrow from C=O bond to O ✓ correct intermediate **AND** curly arrow to H^+ ✓  	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** curly arrow must come from lone pair on H or negative charge on H curly arrow must come from the bond, not the carbon atom curly arrow must come from lone pair on O or negative charge on O and go to H or positive charge on H **Where circles have been placed round charges, this is for clarity only and does not indicate a requirement** **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 negative charge or lone pair on the oxygen atom of the intermediate to H in H_2O **AND** from the O—H bond to the O in H_2O. **Dipole not required on water molecule** Penalise missing –OH on intermediate only **IGNORE** product – already given credit in part (i)

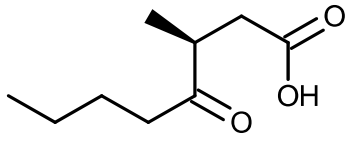
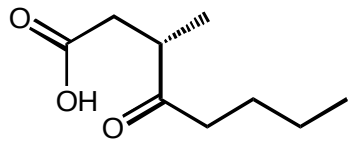
Question			Answer	Mark	Guidance
	(d)		 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW** disubstitution at any positions on benzene ring
			Total	**10**	

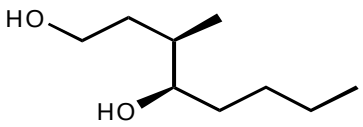
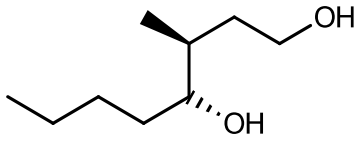
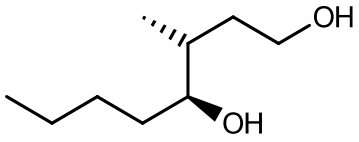
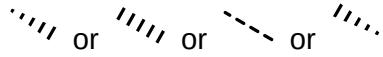
Question			Answer	Mark	Guidance
2	(a)		**FIRST** react **all** with Tollens' reagent **AND** silver mirror/ppt/solid (formed) with compound **D** **OR** with Fehling's/Benedict's solutions **AND** (brick-red/orange) solid/precipitate (formed) with compound **D** ✓ ***NOTE**: eliminates **D***	4	**ALLOW** ammonia + silver nitrate for reagent **ALLOW** black solid/ppt **ALLOW** 'the aldehyde gives a silver mirror' **ALLOW** solid **OR** crystals **OR** ppt as alternatives for precipitate **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous
			 ✓		**DO NOT ALLOW** molecular formulae for organic structures
			THEN react **C** and **E** with H_2SO_4/H^+ **AND** $K_2Cr_2O_7$/ $Cr_2O_7^{2-}$/$Na_2Cr_2O_7$ **AND** colour change **OR** green colour with compound **C** **OR** <u>no</u> change **OR** <u>no</u> reaction **OR** no green colour with compound **E** ✓		**IGNORE** all references to 2,4-dinitrophenylhydrazine/Brady's **ACCEPT** acidified dichromate **ALLOW** blue/green blue **IGNORE** equation for oxidation of **D**
			 ✓		**ALLOW** equation for partial oxidation 

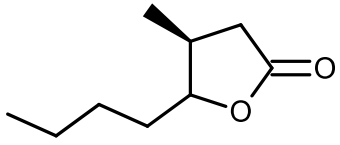
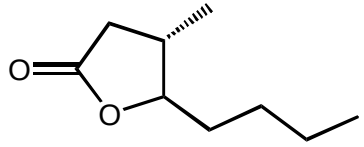
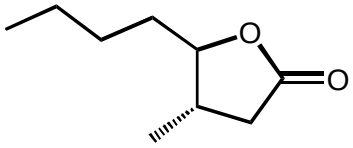
Question			Answer	Mark	Guidance
					ALLOW alternative sequences e.g. **FIRST** react **all** with H_2SO_4 **AND** $K_2Cr_2O_7$ colour change with **C** and **D** *eliminates **E*** At least one correct equation and structure of one product from either reaction required for the second mark. **NB** several possible products for the oxidation of **D** **THEN** react **C** and **D** with Tollens' …… *distinguishes between **C** and **D***
2	**(b)**		 curly arrow from H^- to $C^{(\delta+)}$ of correct C=O group ✓ dipole correct **AND** curly arrow from C=O bond to $O^{(\delta-)}$ ✓  correct intermediate with negative charge on O ✓  correct product ✓	**4**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous First curly arrow must come from either a lone pair on H or negative charge on H **IF** aldehyde reduced **OR** both carbonyls reduced **DO NOT AWARD** first mark (second, third and fourth marks can be awarded **ECF**) **IGNORE** lack of C—H if entirely skeletal **IGNORE** curly arrows in second stage Apply ecf to error in structure e.g. CH_2 missing from the chain or –COOH/-COH instead of –CHO **IGNORE** other products

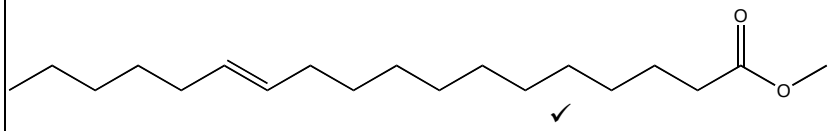
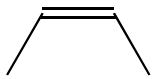
Question			Answer	Mark	Guidance
2	(c)		<table><tr><th>Compound</th><th>C</th><th>D</th><th>E</th></tr><tr><td>Number of peaks</td><td>5</td><td>5</td><td>4</td></tr></table> **all** correct ✓	1	
2	(d)	(i)	• pent-2-ene  **AND**  ✓ • hexa-2,4-diene  ✓  ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** C_2H_5CHO and CH_3CHO
2	(d)	(ii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous
			Total	13	

Question			er	Marks	Guidance
3	(a)	(i)	propane-1,2,3-triol ✓	1	**ALLOW** absence of 'e' after 'propan' **ALLOW** 1,2,3-propanetriol **ALLOW** absence of hyphens 1, 2 and 3 must be clearly separated: **ALLOW** full stops: 1.2.3 **OR** spaces: 1 2 3 **DO NOT ALLOW** 123 **IGNORE** glycerol
		(ii)	  One mark for decenoate salt **OR** decenoic acid ✓ One mark for hexanoate salt **OR** hexanoic acid ✓ One mark for **BOTH correct** products shown as salts (with or without Na^+) ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **DO NOT ALLOW** *cis* structure  **ALLOW** **OR**  **DO NOT ALLOW** (covalent bond)  **ALLOW** delocalised carboxylate **IGNORE** glycerol
	(b)		one of the fatty acids is *trans* ✓ which may increase / cause / produce (the level of) 'bad'/LDL cholesterol ✓ **QWC** cholesterol MUST be spelt correctly	2	**ALLOW** one of the products is TRANS **ALLOW** reduces (the level of) 'good'/HDL cholesterol
			Total	**6**	

Question			Answer	Marks	Guidance
4	(a)	(i)	 **F** = **AND** reagent $NaBH_4$ ✓ **NB One mark for BOTH**	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous Wedge out of the paper is required i.e.( or  or ) **DO NOT ALLOW** dashed wedge on methyl group in this orientation ( or  or  or ) **ALLOW** 
		(ii)	Colour changes from orange to green / blue / green blue ✓	1	
		(iii)	to ensure <u>carboxylic acid</u> is formed **OR** prevents formation of <u>aldehyde</u> **OR** distillation only makes the <u>aldehyde</u> ✓	1	
		(iv)	(nucleophilic) addition ✓	1	**ALLOW** redox **OR** reduction
	(b)		2,4-DNP(H) ✓ orange precipitate ✓	2	**ALLOW** Brady's (reagent) **ALLOW** orange/red/yellow for colour of the 2,4-DNP(H) precipitate **ALLOW** solid/crystals in place of precipitate **IGNORE** any reference to recrystallising/melting points

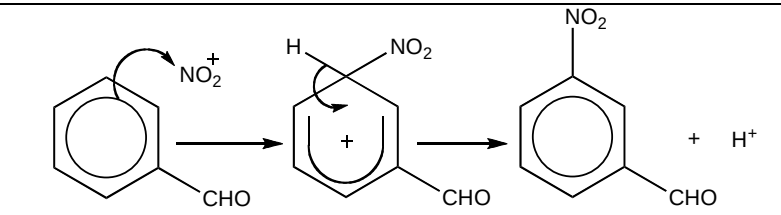
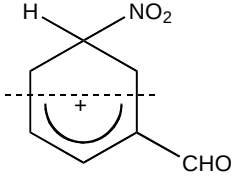
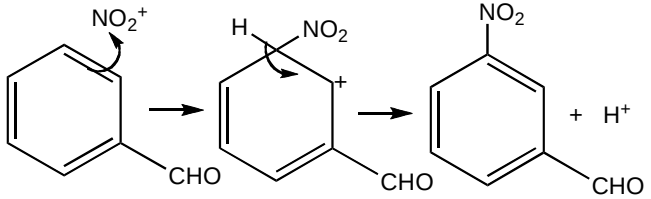
Question			Answer	Marks	Guidance
4	(c)	(i)	One of:  **OR**  **OR**  for one mark ✓ optical (isomerism) ✓	2	For bold wedge **ALLOW**  For dashed wedge **ALLOW**  **DO NOT ALLOW** any other representation of the structure, *i.e.* anything not skeletal **ALLOW** open wedges **ALLOW** isomers shown in any alternative correct orientation
		(ii)	If answer = 63.5 award 3 marks moles of **E** used = 4.56/160(.0) / 0.0285 (mol) ✓ moles of **G** formed = 3.15/174(.0) / 0.0181 (mol) ✓ yield = 0.0181/0.0285 × 100% / 63.5% ✓	3	0.0285 mol is exact calculator value 0.0181 mol is to 3sf (calculator value 0.0181034…) **IGNORE** trailing numbers in this answer **ALL ANSWERS MUST** be to a minimum of 3sf, the final answer must be to 3 sf (calculator value gives 63.520871%) (rounding of moles of **G** gives 63.508772%) **ALLOW** ecf from incorrect Mr or moles unless the yield is >100

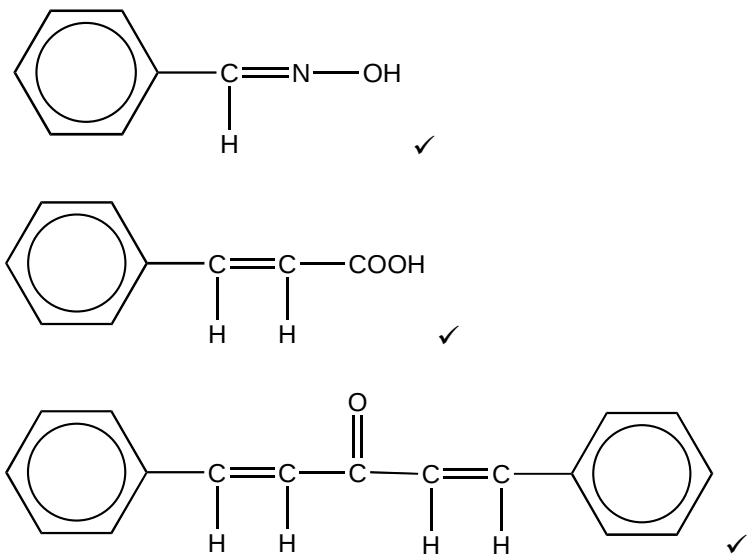
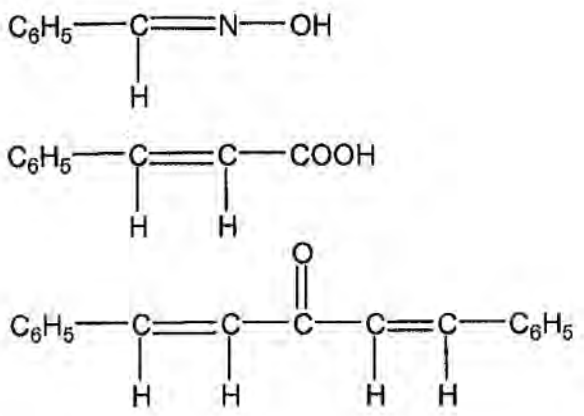
Question			Answer	Marks	Guidance
		(iii)	 for first mark ✓ Other product = H_2O for second mark ✓	2	**ALLOW** abbreviation of alkyl chain Wedge out of the paper is required i.e.( or  or ) **DO NOT ALLOW** dashed wedge on methyl group in this orientation ( or  or  or ) **ALLOW**  Be careful with orientation of lactone: **ALLOW** 
			Total	**13**	

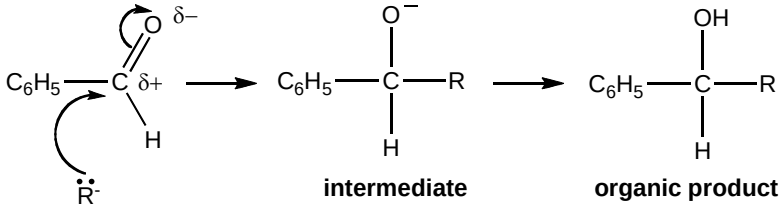
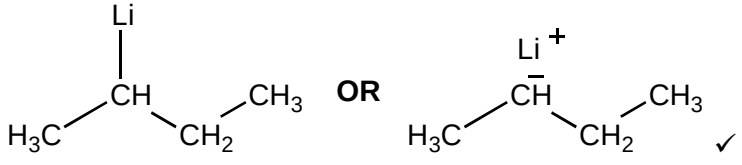
Question			er	Marks	Guidance
5	(a)	(	 ✓ *cis*-isomer has Hs on same side **OR** *cis*-isomer has branches on same side **OR** *cis*-isomer has same groups on same side **OR** *cis*-isomer has lowest priority groups on same side **OR** *cis*-isomer has highest priority groups on same side ✓	2	**ALLOW** *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			er	Marks	Guidance
	(b)	(	27	1	
		(ii)	8	1	
	(c)	(	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			er	Marks	Guidance
		(iii)	**1st step** *reagent*: $NaBH_4$ ✓ *functional groups*: **alde yde** 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*: **alcoho** 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			er	Marks	Guidance
6	(a)		 curly arrow from ring to NO_2^+ **M1** ✓ correct intermediate curly arrow from C-H bond back to reform ring **M2** ✓ **M3** ✓ correct products **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			er	Marks	Guidance
	(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			er	Marks	Guidance
	(d)	(	 **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**	