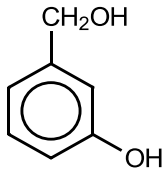
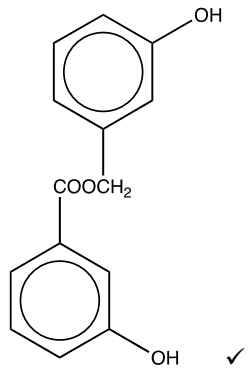
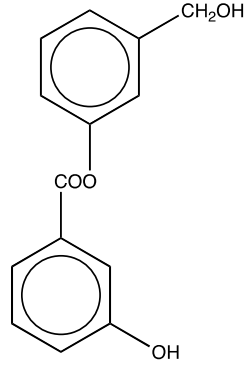
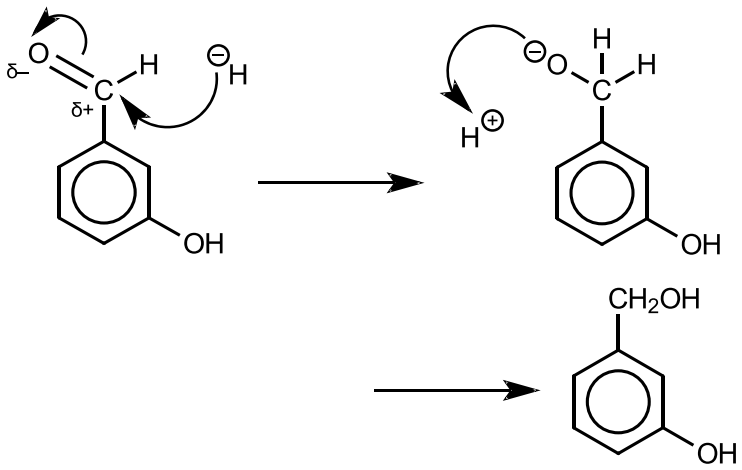
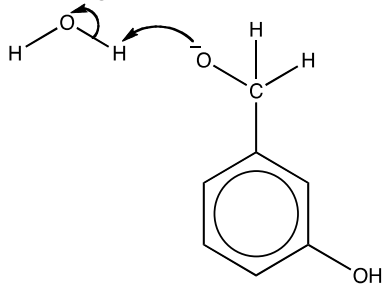
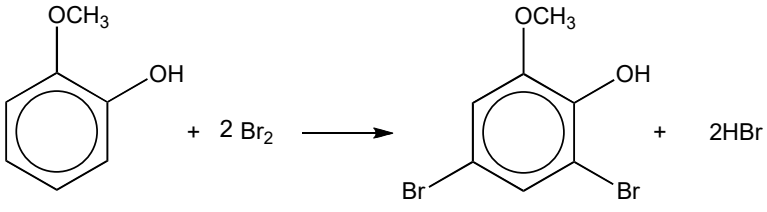
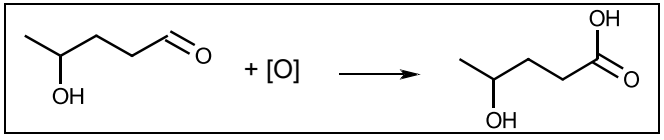
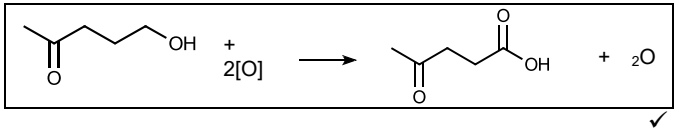
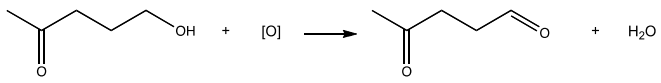
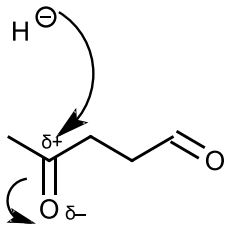
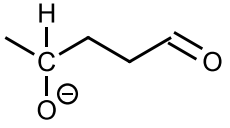
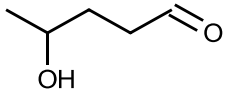
| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | | (Relative) solubility (in stationary phase) ✓ | 1 | **ALLOW** how well the compound dissolves<br>**IGNORE** retention time **AND** partition<br>**DO NOT ALLOW** adsorption **OR** absorption |
| | (b) | (i) | Compound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

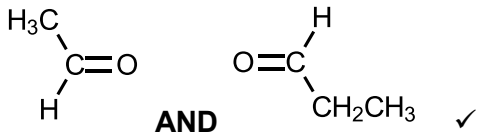
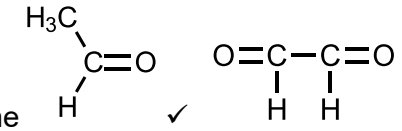
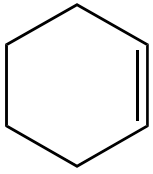
| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| | (c) | (i) | reagent = $K_2Cr_2O_7$ **AND** $H_2SO_4$ ✓ | 3 | **ALLOW** acidified dichromate<br>**ALLOW** $H^+$/any acid<br>**IGNORE** concentration of acid<br>**ALLOW** $Na_2Cr_2O_7$ /$Cr_2O_7^{2-}$ /(potassium **OR** sodium) dichromate((VI))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

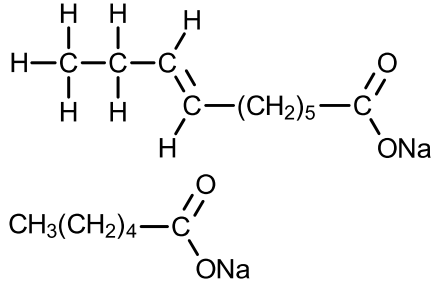
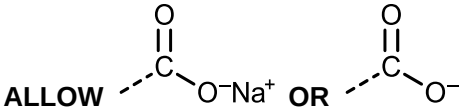
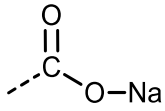
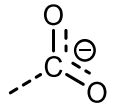
| Question | Answer | Mark | Guidance |
|---|---|---|---|
| (ii) | curly arrow from $H^-$ to $C^{\delta+}$ ✓<br><br>dipole **AND** curly arrow from C=O bond to O ✓<br><br>correct intermediate **AND** curly arrow to $H^+$ ✓<br><br>  <br> | 3 | **ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**<br>curly arrow must come from lone pair on H or negative charge on H<br><br>curly arrow must come from the bond, not the carbon atom<br><br>curly arrow must come from lone pair on O or negative charge on O and go to H or positive charge on H<br><br>**Where circles have been placed round charges, this is for clarity only and does not indicate a requirement**<br><br>**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous<br><br>**ALLOW** for second stage<br>  <br><br><br>**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**<br><br>Penalise missing –OH on intermediate only<br><br>**IGNORE** product – already given credit in part (i) |

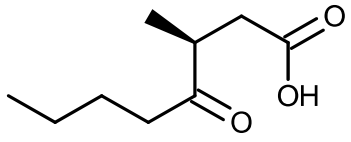
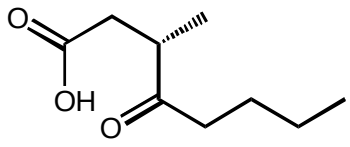
| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| | (d) | |  ✓ | 1 | **ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous<br>**ALLOW** disubstitution at any positions on benzene ring |
| | | | **Total** | **10**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

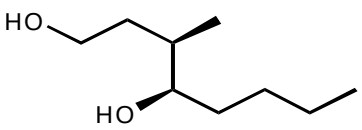
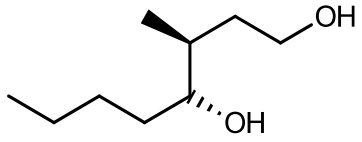
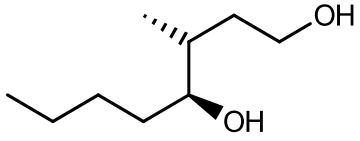
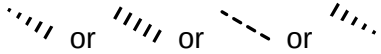
| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | | **FIRST** react **all** with<br>Tollens' reagent **AND** silver mirror/ppt/solid (formed) with compound **D**<br>**OR** with Fehling's/Benedict's solutions **AND** (brick-red/orange) solid/precipitate (formed) with compound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

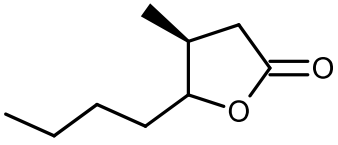
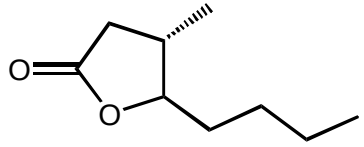
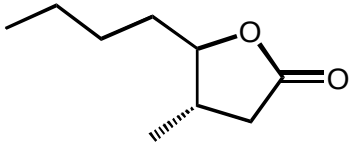
| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| | | | | | **ALLOW** alternative sequences<br>e.g. **FIRST** react **all** with $H_2SO_4$ **AND** $K_2Cr_2O_7$<br>colour change with **C** and **D**<br>*eliminates **E***<br><br>At least one correct equation and structure of one product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

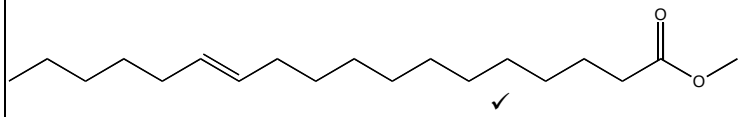
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>2</td><td>(c)</td><td></td><td>
<table>
<tr><td>Compound</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>Number of peaks</td><td>5</td><td>5</td><td>4</td></tr>
</table>
all correct ✓</td><td>1</td><td>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

| Question | | | er | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | (i) | propane-1,2,3-triol ✓ | 1 | **ALLOW** absence of 'e' after 'propan'<br>**ALLOW** 1,2,3-propanetriol<br>**ALLOW** absence of hyphens<br>1, 2 and 3 must be clearly separated:<br>**ALLOW** full stops: 1.2.3 **OR** spaces: 1 2 3<br>**DO NOT ALLOW** 123<br>**IGNORE** glycerol |
| | | (ii) |  <br>One mark for decenoate salt **OR** decenoic acid ✓<br>One mark for hexanoate salt **OR** hexanoic acid ✓<br>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<br>**DO NOT ALLOW** *cis* structure<br>  <br>**DO NOT ALLOW**  (covalent bond)<br>  <br>**ALLOW** delocalised carboxylate<br>**IGNORE** glycerol |
| | (b) | | one of the fatty acids is *trans* ✓<br>which may increase / cause / produce (the level of) 'bad'/LDL cholesterol ✓<br>**QWC** cholesterol MUST be spelt correctly | 2 | **ALLOW** one of the products is TRANS<br>**ALLOW** reduces (the level of) 'good'/HDL cholesterol |
| | | | **Total** | **6** | |

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

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

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

| Question | | | er | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | ( |  ✓<br><br>*cis*-isomer has Hs on same side<br>**OR** *cis*-isomer has branches on same side<br>**OR** *cis*-isomer has same groups on same side<br><br>**OR** *cis*-isomer has lowest priority groups on same side<br>**OR** *cis*-isomer has highest priority groups on same side ✓ | 2 | **ALLOW** *trans*-isomer has Hs on opposite sides<br>**OR** *trans*-isomer has branches on opposite sides<br>**OR** *trans*-isomer has same groups on opposite sides<br>**DO NOT ALLOW** 'similar groups' for 'same groups'<br>**OR** *trans*-isomer has lowest priority groups on opposite sides<br>**OR** *trans*-isomer has highest priority groups on opposite sides ✓<br><br>For explanation, **ALLOW** a clear diagram, *ie*:<br>  <br>*cis*<br>**ALLOW** response in terms of packing, e.g. molecules/chains of *trans*-isomer pack close together<br>**OR**<br>molecules/chains of *cis*-isomer do **not** pack closely together<br>**DO NOT ALLOW** 'carbon atoms' for 'molecules/chains' |
| | | (ii) | heart disease**/**strokes ✓ | 1 | **ALLOW** any named heart/circulatory complaint<br>e.g. atheroma, atheroscleros<br>**ALLOW** increase in **bad** cholesterol/LDL<br>**ALLOW** high in LDLs<br>**ALLOW** fat lining arteries<br>**ALLOW** high blood pressure<br>**ALLOW** hypertension<br>**IGNORE** reference to HDLs and cholesterol on its own |

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

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

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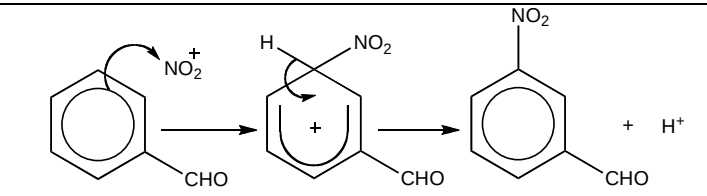
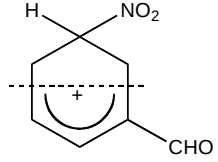
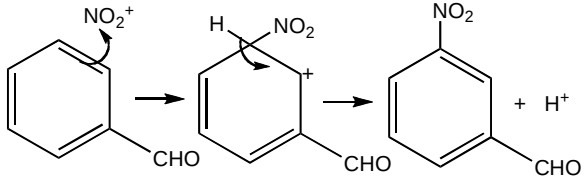
| **6** | (a) | |  <br><br>curly arrow from ring to $NO_2^+$<br>correct intermediate curly arrow from C-H bond back to reform ring<br>correct products<br>**M1** ✓ **M2** ✓ **M3** ✓ **M4** ✓<br>---<br>**Note**:<br>**ALLOW M1**, **M2 AND M3** for benzene **OR ANY** substituted benzene compound<br>For **M4**,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

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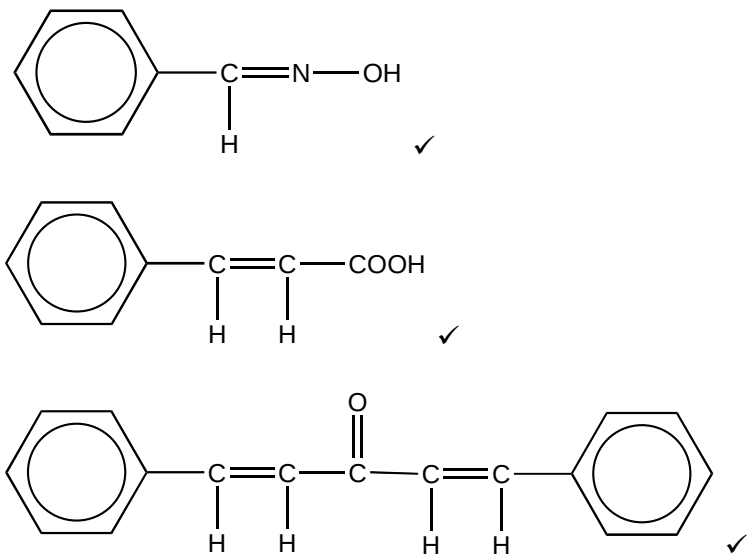
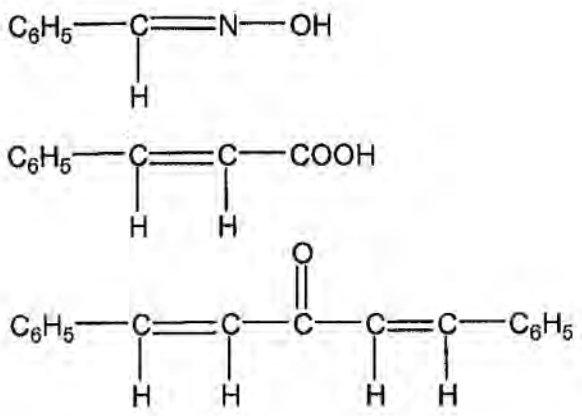
| | (b) | | $2\ C_6H_5CHO + KOH \longrightarrow C_6H_5CH_2OH + C_6H_5COOK$<br>**OR**<br>$2\ C_6H_5CHO + OH^- \longrightarrow C_6H_5CH_2OH + C_6H_5COO^-$<br><br>1 mark for $C_6H_5CH_2OH$ ✓<br><br>1 mark for $C_6H_5COOK$ **OR** $C_6H_5COOH$ **OR** $C_6H_5COO^-$ ✓<br><br>1 mark for complete fully correct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

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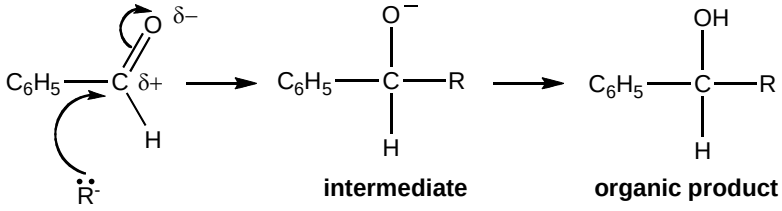
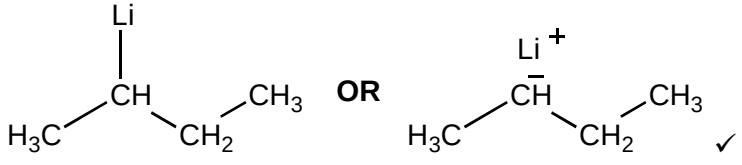
| | (d) | ( |  <br>**intermediate** **organic product**<br><br>1 mark for curly arrow from $R^-$ to C of C=O (lone pair not necessary) ✓<br><br>1 mark for correct dipoles on C=O **AND** curly arrow from double bond to $O^{\delta-}$ ✓<br><br>1 mark for correct intermediate with – charge on O ✓<br><br>1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