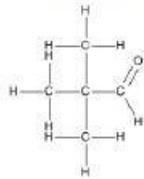
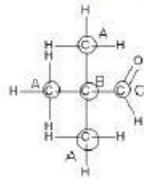
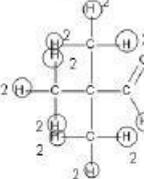




## Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>displayed formula of aldehyde</li> <li>three different carbon environments indicated</li> <li>two different proton environments indicated</li> <li>no splitting as there are no hydrogens on the adjacent carbon atom(s)</li> </ul>	<p>Example of displayed formula:</p>  <p>Allow CH<sub>3</sub> groups but aldehyde group must be displayed</p> <p>Example of three carbon environments:</p>  <p>Example of two proton environments:</p>  <p>Stand alone mark</p>	(4)

Q2.

Question Number	Answer	Mark
(i)	<p><b>The only correct answer is B</b> (alkaline iodine solution)</p> <p><i>A is not correct because this oxidising agent would react with phenylethanal and not with phenylethanone which is the wrong way round</i></p> <p><i>C is not correct because test is for aldehydes and so would react with phenylethanal and not with phenylethanone which is the wrong way round</i></p> <p><i>D is not correct because test is for aldehydes and so would react with phenylethanal and not with phenylethanone which is the wrong way round</i></p>	(1)



Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"><li>• formation of yellow/orange/red (crystalline) precipitate (1)</li><li>• (Filter then) recrystallisation of products (1)</li><li>• determination of melting temperature (1)</li><li>• comparison (and hence identification) from use of database/known values (1)</li></ul>	<p>Colour and state are both required Allow solid for ppt Ignore any conditions given with the use of 2,4-DNPH</p> <p>Penalise M3 if any reference to boiling temperature</p> <p>Award only in the context of melting temperature of the hydrazones or as a TE of boiling temperature</p> <p>Max 3 out of 4 if test is only carried out with one of the carbonyls</p>	(4)



Question Number	Answer	Additional Guidance	Mark																				
* (iii)	<p>This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1"> <thead> <tr> <th>Number of indicative marking points seen in answer</th> <th>Number of marks awarded for indicative marking points</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table border="1"> <thead> <tr> <th></th> <th>Number of marks awarded for structure of answer and sustained lines of reasoning</th> </tr> </thead> <tbody> <tr> <td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td> <td>2</td> </tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning</td> <td>1</td> </tr> <tr> <td>Answer has no linkages between points and is unstructured</td> <td>0</td> </tr> </tbody> </table>	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 lines of reasoning	Answer shows a coherent 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	<p>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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).</p> <p>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. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).</p> <p>If there is no mention of protons/hydrogens in the response then deduct one structure and reasoning mark</p>	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
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	<p><b>Indicative content</b></p> <p><b>Similarities</b></p> <ul style="list-style-type: none"> <li>• <b>IP1:</b> aromatic hydrogens will give similar/same peaks</li> <li>• <b>IP2:</b> both have a peak in the range 1.7-3.0 (ppm) (due to the hydrogen of the H-C-C=O type)</li> </ul> <p><b>Differences</b></p> <ul style="list-style-type: none"> <li>• <b>IP3</b> (Hydrogen environments): Phenylethanone has one less peak/hydrogen environment than phenylethanal</li> <li>• <b>IP4</b> (Splitting patterns): a singlet for phenylethanone but a doublet and a triplet in phenylethanal</li> <li>• <b>IP5</b> (Peak area ratios): relative peak (area) ratio in phenylethanone is 3 but in phenylethanal the peak (area) ratio is 2 to 1</li> <li>• <b>IP6</b> (Chemical shifts): (Only) phenylethanal has an aldehyde (hydrogen) peak in the range 9 – 10.1 (ppm)</li> </ul>	<p>Ignore references to C<sup>13</sup> nmr Accept annotations on a structure towards crediting the following IPs Allow either a single chemical shift value or a range within the stated values Penalise incorrect chemical shifts</p> <p>Both have peaks in the range 6.5-8.4 (ppm) Ignore any splitting description</p> <p>Ignore any splitting pattern given for this peak to award this mark</p> <p>Allow any difference of one in the number of peaks stated</p> <p>All these splitting patterns required for this IP</p> <p>Ignore the splitting pattern for this IP and ignore any peak areas given for the aryl hydrogens</p> <p>Ignore the splitting pattern for this IP</p>	
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Q3.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"><li>Reagent: lithium tetrahydridoaluminate(III) /LiAlH<sub>4</sub> <b>(1)</b></li><li>Conditions: (dry) ether/ethoxyethane <b>(1)</b></li></ul>	<p>Allow lithium aluminium hydride</p> <p>Accept sodium tetrahydridoborate /sodium borohydride/ NaBH<sub>4</sub> In water/alcohol for 2 marks</p> <p>Ignore reference to addition of acid after use of LiAlH<sub>4</sub> in dry ether</p> <p>Do not award with additional reagents</p> <p>Ignore heat</p> <p>The mark for conditions is dependent on correct reagent or near miss such as incorrect formula LiAlH<sub>3</sub>/LiAlH/LiAl</p>	<b>(2)</b>



Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>similar molar masses so the number of electrons is similar/same resulting in similar London forces (1)</li> <li>propanone (and ethanoic acid) form permanent dipole(-dipole) forces (1)</li> <li>(only) ethanoic acid forms (intermolecular) hydrogen bonding (1)</li> <li>which is stronger so requires more <b>energy</b> to break (giving a higher boiling temperature) (1)</li> </ul>	<p>Allow van der Waals' forces / dispersion forces / instantaneous dipole-induced dipole forces</p> <p>Ignore reference to ethanoic acid having greater London forces</p> <p>Ignore reference to hydrogen bonding to water by propanone Penalise abbreviation pd-d once only</p> <p>Ignore references to ethanoic acid dimerization</p> <p>Reference to energy must be linked to the breaking of hydrogen bonds</p>	(4)



Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>forms hydrogen bonds with water (1)</li> <li>diagram of hydrogen bond (1)</li> </ul>	<p>Allow H bonds for hydrogen bonds</p> $\begin{array}{c} \text{H}_3\text{C} \\ \diagdown \\ \text{C}=\text{O} \cdots \text{H}-\text{O}-\text{H} \\ \diagup \\ \text{H}_3\text{C} \end{array}$ <p>Ignore bond angle and missing dipoles and missing lone pair</p> <p>Do not award incorrect dipoles Do not award incorrect propanone and/or water structure Do not award if second hydrogen bond drawn to the hydrogen of the CH<sub>3</sub></p>	(2)

## Q5.

Question Number	Answer	Additional Guidance	Mark
	<p>A description that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>(add a solution of) iodine and alkali / sodium hydroxide / potassium hydroxide / hydroxide ions (and warm) (1)</li> <li>or (add a solution of) potassium iodide in sodium chlorate(I) (and warm) (1)</li> <li>(only) pentan-2-one give a (pale) yellow precipitate / ppt(e) / solid</li> </ul>	<p>Allow names or formulae but if both are given, both must be correct</p> <p>Stand alone mark Allow antiseptic smell</p> <p>Ignore observation for pentan-3-one unless also stated that it gives a yellow precipitate</p>	(2)



Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>curly arrow from lone pair on C of <math>\text{CN}^-</math> to C of ketone group (1)</li> <li>curly arrow from <math>\text{C}=\text{O}</math> to, or just beyond, O (1)</li> <li>intermediate (1)</li> <li>curly arrow from lone pair on <math>\text{O}^-</math> to H and curly arrow from <math>\text{H}-\text{CN}</math> bond to anywhere on CN (1)</li> </ul>	<p>Example of mechanism:</p> <p>Allow <math>\text{C}_3\text{H}_7</math> and <math>\text{CH}_3</math> for propyl and methyl groups</p> <p>Allow CN bond displayed</p> <p>Ignore correct dipoles, penalise an incorrect dipole once only</p> <p>Do not award M3 if <math>\text{C}^+</math> is shown on intermediate</p> <p>For M4, allow curly arrow from lone pair on <math>\text{O}^-</math> to <math>\text{H}^+</math> ion / <math>\text{H}_2\text{O}</math> molecule</p> <p>Penalise incorrect ketone once only in M3 intermediate</p> <p>Penalise curly arrow from -ve charge instead of lone pair once only</p>	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>pentan-2-one / ketone is planar about the carbonyl carbon (1)</li> <li>so the <math>\text{CN}^-</math> / nucleophile attacks (equally) from above and below / either side (of the plane) (1)</li> </ul>	<p>Allow bonds about <math>\text{C}=\text{O}</math> are (trigonal) planar or the carbonyl carbon is (trigonal) planar</p> <p>Do not award planar molecule / reference to planar intermediate / ion</p> <p>Do not award multiple directions</p>	(2)



Q7.

Question Number	Acceptable Answers	Additional Guidance	Mark																				
*	<p>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1"> <thead> <tr> <th>Number of indicative marking points seen in answer</th> <th>Number of marks awarded for indicative marking points</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>The following table shows how the marks should be awarded for structure and lines of reasoning.</p> <table border="1"> <thead> <tr> <th></th> <th>Number of marks awarded for structure of answer and sustained line of reasoning</th> </tr> </thead> <tbody> <tr> <td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td> <td>2</td> </tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning.</td> <td>1</td> </tr> <tr> <td>Answer has no linkages between points and is unstructured.</td> <td>0</td> </tr> </tbody> </table>	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	<p>Guidance on how the mark scheme should be applied:</p> <p>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).</p> <p>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).</p>	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
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	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																						
	<p><b>Comment:</b> Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning</p>	<p>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</p>																					



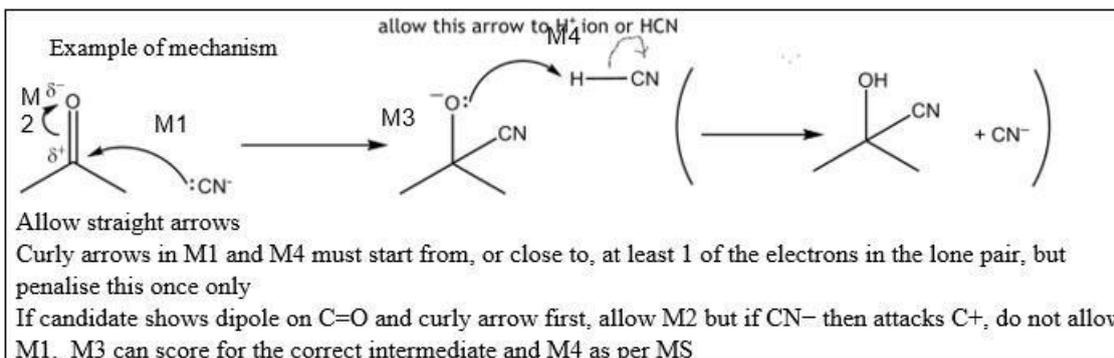
	<p><b>Indicative content</b></p> <ul style="list-style-type: none"> <li>• <b>IP1 Reagents and conditions for oxidation</b> – acidified potassium dichromate(VI) / <math>K_2Cr_2O_7</math> and <math>H^+/H_2SO_4</math> or acidified sodium dichromate(VI) / <math>Na_2Cr_2O_7</math> and <math>H^+/H_2SO_4</math> or Fehling's solution / Benedict's solution or Tollens' reagent / ammoniacal silver nitrate / <math>Ag(NH_3)_2^+</math></li> </ul>	<p>or 2 indicative points would score zero marks for reasoning.</p>	
	<ul style="list-style-type: none"> <li>• <b>IP2 Oxidation of aldehyde</b> – structure of pentanoic acid</li> <li>• <b>IP3 Oxidation of ketone</b>–pentan-3-one / ketone is not (easily) oxidised</li> <li>• <b>IP4 Reagents and conditions for reduction</b> – lithium tetrahydridoaluminate(III) / lithium aluminium hydride and dry ether / ethoxyethane (followed by a dilute acid) or sodium tetrahydridoborate(III) / sodium borohydride and aqueous / methanol solution (followed by a dilute acid)</li> <li>• <b>IP5 Reduction of aldehyde</b> – structure of pentan-1-ol</li> <li>• <b>IP6 Reduction of ketone</b> – structure of pentan-3-ol</li> </ul>	<p>Reagents - Allow names or formulae but if both are given, both must be correct</p> <p>Products - Allow any combination of displayed and structural formulae / skeletal formulae Allow <math>C_4H_9</math> / <math>C_3H_7</math> for the alkyl groups</p> <p>Allow acidified dichromate(VI) ions / <math>Cr_2O_7^{2-}</math> and <math>H^+/H_2SO_4</math> Allow acidified manganate(VII) ions / <math>MnO_4^-</math> and <math>H^+/H_2SO_4</math> Ignore reference to heat Do not award just <math>Cu^{2+}</math> for Fehling's / Benedict's</p> <p><math>CH_3CH_2CH_2CH_2COOH</math></p>	

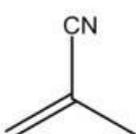
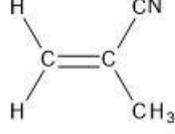
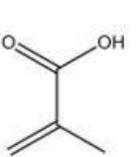
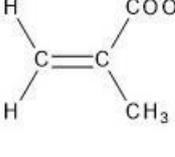


		Allow lital Ignore hydrogen and platinum (catalyst) Ignore reference to heat  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  $\text{CH}_3\text{CH}_2$ $\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$	
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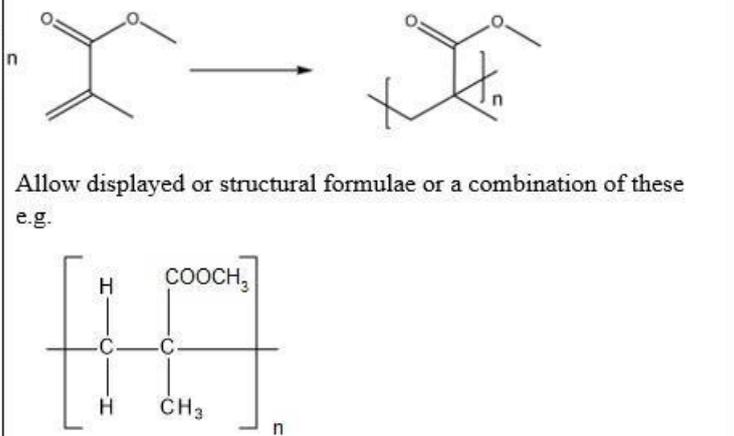
Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> <li>• curly arrow from lone pair on C of <math>\text{CN}^-</math> ion to C of <math>\text{C}=\text{O}</math> (1)</li> <li>• dipole on <math>\text{C}=\text{O}</math> and curly arrow from <math>\text{C}=\text{O}</math> bond to or just beyond O (1)</li> <li>• intermediate structure (1)</li> <li>• curly arrow from lone pair on O to H of <math>\text{HCN}</math> and curly arrow from <math>\text{H}-\text{C}</math> bond to anywhere on <math>\text{CN}</math> (1)</li> </ul>	Penalise omission of lone pair once in M1 and M4 Penalise use of single-headed arrows only once Penalise use of incorrect nucleophile once only in M1 e.g. $\text{OH}^-$ Allow skeletal, displayed or structural formulae  Allow $\text{CN}^-$ to attack from any angle Allow $\text{CN}$ triple bond displayed Do not award curly arrow from lone pair on N Do not award $\text{CN}^{\delta-}$ Ignore missing lone pair on O Ignore connectivity for vertical $\text{CN}$ group if M1 awarded Do not award $\text{O}^{\delta-}$  Allow curly arrow from lone pair on $\text{O}^-$ to $\text{H}^+$ Ignore dipole on $\text{HCN}$ Ignore products, even if incorrect	(4)



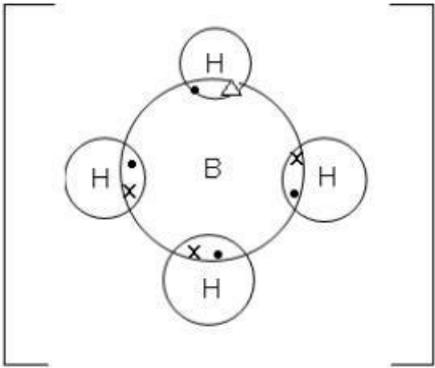
Question number	Answer	Additional Guidance	Mark
(ii)			(6)
Reagent 2	(conc) phosphoric acid / H <sub>3</sub> PO <sub>4</sub> (conc) sulfuric acid / H <sub>2</sub> SO <sub>4</sub> aluminium oxide / Al <sub>2</sub> O <sub>3</sub> (1)	Ignore connectivity of groups All marks are stand alone Allow 'alumina' Do not award steam / water Do not award dilute for either acid	
Structure of compound A	 (1) 	Allow structural, displayed or any combination of structural, displayed or skeletal for Compounds A and B	
Reaction type 3	(acid) Hydrolysis (1)	Do not award hydration / halogenation for M3	
Structure of compound B	 (1) 	Allow TE for M4 based on incorrect M2 structure provided the nitrile group has been hydrolysed correctly and no other changes	
Reagent 4	CH <sub>3</sub> OH / methanol (1)	Allow	
Reaction type 4	Esterification / condensation (1)	additionelimination for condensation in M6	



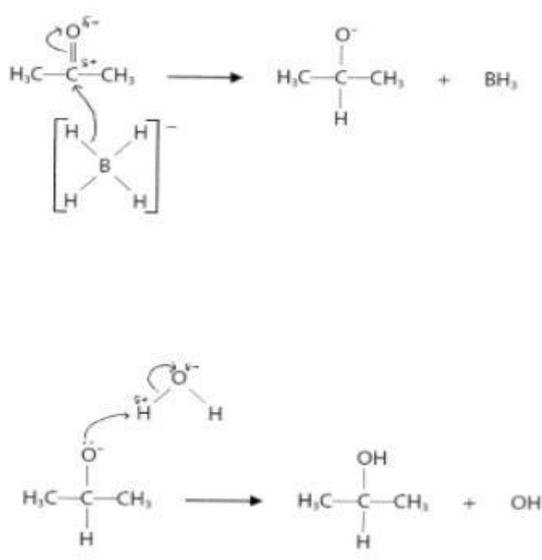
Question Number	Answer	Additional Guidance	Mark
(iii)	correct • repeat unit shown • (1) equation balanced (1)	 <p>Allow displayed or structural formulae or a combination of these e.g.</p> $\left[ \begin{array}{c} \text{H} \quad \text{COOCH}_3 \\   \quad   \\ \text{---C---C---} \\   \quad   \\ \text{H} \quad \text{CH}_3 \end{array} \right]_n$ <p>Do not award 2 as the balancing number</p>	(2)



Q9.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> <li>dot-and-cross diagram</li> </ul>	<p><u>Example of diagram</u></p>  <p>Electrons must have the correct symbols i.e. 3 bonds with • and x and 1 bond with • and Δ</p> <p>Circles do not need to be shown</p> <p>Allow missing brackets but charge needs to be shown</p> <p>Allow charge anywhere on or close to diagram</p> <p>Ignore lines representing covalent bonds e.g.</p> <p style="margin-left: 20px;">x •</p> <p>Ignore missing atom labels / inner shell of 2 electrons on B</p>	<b>(1)</b>



Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> <li>• curly arrow from B-H bond to C of C=O (1) Allow curly arrow from B-H bond to H and curly arrow from H to C</li> <li>• dipole on C=O (1) and curly arrow from C=O bond to or just beyond O</li> <li>• lone pair on O<sup>-</sup> (1) and curly arrow from lone pair to H of H<sub>2</sub>O</li> <li>• curly arrow from O-H bond to O (1) and dipole on H-O bond</li> </ul>	<p>Example of mechanism</p>  <p>Allow curly arrow from any B-H bond</p> <p>Ignore lone pair on O in H<sub>2</sub>O</p> <p>Penalise half-headed curly arrow once only</p>	(4)