

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	sulfuric acid / fuming H ₂ SO ₄ / oleum / H ₂ S ₂ O ₇	Conc. (for fuming) Fuming dilute sulfuric acid Just sulfuric acid Just H ₂ SO ₄	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Sulfur is δ^+ and on at least one oxygen δ^- (1) Oxygen is (much) more electronegative than sulfur ALLOW Oxygen is very electronegative (1)	Full + or – charge(s) 1/3 – on each oxygen	2

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1(a)(iii)	The sulfur trioxide can accept a pair of electrons OR (Three oxygen atoms so) sulfur has a large δ or partial / slight positive charge OR π bonds allow S–O bonds to be polarized more easily ALLOW Electron-deficient sulfur	An electron	1

Marks for (b)(i) and (b)(ii) can be awarded from either of the two annotated diagrams on item

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1(b)(i)	<p>First curly arrow as shown to start inside the hexagon to the S atom (1)</p> <p>Second curly arrow from bond to O (i.e. not from the S atom itself) (1)</p> <p>ALLOW Second curly arrow to any of the three O atoms in SO₃</p> <p>IGNORE A full + charge on S</p>		2

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	$\text{C}_6\text{H}_5\text{SO}_3\text{H} + 3\text{NaOH} \rightarrow \text{C}_6\text{H}_5\text{ONa} + \text{Na}_2\text{SO}_3 + 2\text{H}_2\text{O}$ <p style="text-align: right;">(1)</p> <p>ALLOW Charges on $\text{C}_6\text{H}_5\text{O}^-\text{Na}^+$</p> $\text{C}_6\text{H}_5\text{ONa} + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{NaCl}$ <p style="text-align: right;">(1)</p> <p>ALLOW $\text{C}_6\text{H}_5\text{O}^- + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{Cl}^-$</p> <p>OR</p> $\text{C}_6\text{H}_5\text{O}^- + \text{H}^+ \rightarrow \text{C}_6\text{H}_5\text{OH}$	Charges on $\text{C}_6\text{H}_5\text{SO}_3\text{H}$	2

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	<p>Any two from:</p> <p>(Both) products useful / both are useful / propanone is useful</p> <p>So less waste / high(er) atom economy</p> <p>Fewer steps / one step / does not require many steps (in Hock synthesis)</p> <p>Continuous rather than a batch process</p> <p style="text-align: right;">(2)</p> <p>IGNORE "Only one waste product in Hock" Comments relating to hazardousness of reactants / safety / energy requirements References to yield References to efficiency References to rate</p>	Cheaper	2

Question Number	Acceptable Answers	Reject	Mark
2(a)	2,6-dimethylhept-5-enal (2) Either part scores (1) e. 2,6-dimethyl (1) hept-5-enal (1) IGNORE missing/misplaced/misused hyphens or commas ALLOW ene for en ALLOW methy or methly for methyl		2

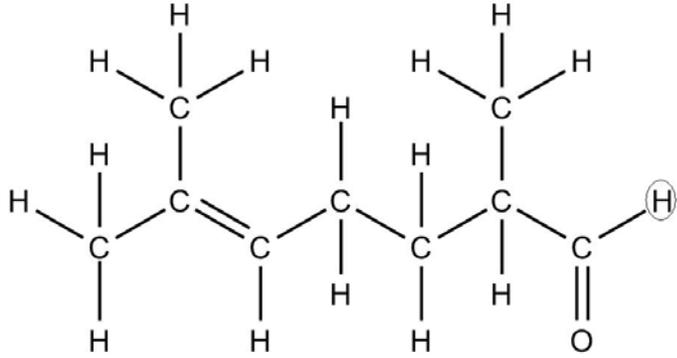
Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	$\text{CH}_3\text{C}(\text{CH}_3)=\text{CHCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ (1) OR $\text{CH}_3\text{C}(\text{CH}_3)\text{CHCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ OR $\text{CH}_3\text{C}(\text{CH}_3)=\text{CHCH}_2\text{CH}_2\text{C}(\text{CH}_3)\text{HCH}_2\text{OH}$ ALLOW displayed or skeletal formulae $\text{K}_2\text{Cr}_2\text{O}_7/\text{Na}_2\text{Cr}_2\text{O}_7/\text{name}$ (oxidation state must be correct if given (VI)) (1) This is a stand alone mark $\text{H}_2\text{SO}_4/\text{name}$ (ignore any references to concentration) (1) ALLOW H^+ and $\text{Cr}_2\text{O}_7^{2-}$ (2) 'Acidified dichromate' (1)	$\text{C}_9\text{H}_{18}\text{O}$ KMnO_4 (0) for last 2 marks HCl (0) for 3 rd mark	3

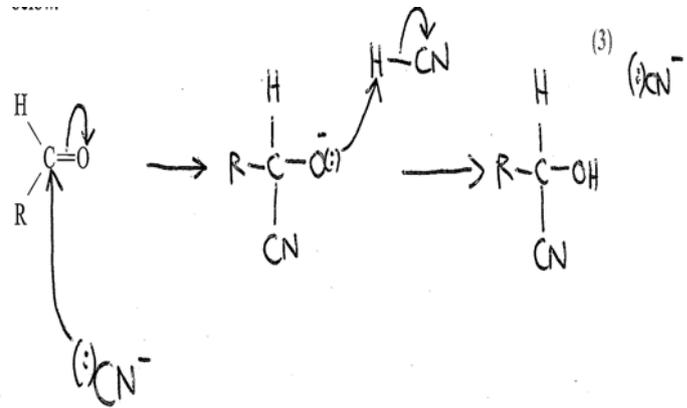
Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	(Steam) distil off melonal (as it forms) Allow add a limited amount of oxidizing agent/excess alcohol/excess X (1) To prevent further oxidation/To prevent carboxylic acid forming (1) Stand alone marks		2

Question Number	Acceptable Answers	Reject	Mark									
2(c)	<table border="1"> <thead> <tr> <th>Wavenumber range / cm^{-1}</th> <th>Bond</th> <th>Function group present in melonal</th> </tr> </thead> <tbody> <tr> <td>1740 – 1720 OR 2900 – 2820 / 2775 – 2700</td> <td>C=O C-</td> <td>(saturated) Aldehyde/CHO</td> </tr> <tr> <td>1669 – 1645 OR 3095 - 3010</td> <td>C=C C-</td> <td>Alkene ALLOW 'carbon to carbon double bond'</td> </tr> </tbody> </table>	Wavenumber range / cm^{-1}	Bond	Function group present in melonal	1740 – 1720 OR 2900 – 2820 / 2775 – 2700	C=O C-	(saturated) Aldehyde/CHO	1669 – 1645 OR 3095 - 3010	C=C C-	Alkene ALLOW 'carbon to carbon double bond'	(1)	Just carbonyl
	Wavenumber range / cm^{-1}	Bond	Function group present in melonal									
	1740 – 1720 OR 2900 – 2820 / 2775 – 2700	C=O C-	(saturated) Aldehyde/CHO									
1669 – 1645 OR 3095 - 3010	C=C C-	Alkene ALLOW 'carbon to carbon double bond'										
(1)	Just C=C in 3 rd column											
<p>ALLOW any single value or range within the ranges above</p> <p>ALLOW one mark if both wavenumber ranges and bond columns are correct but neither bond identified</p>												

Question Number	Acceptable Answers	Reject	Mark
2(d)	$\text{C}_3\text{H}_5\text{O}^+ / \text{CH}_3\text{CHCHO}^+$ (1) $\text{C}_6\text{H}_{11}^+$ (1) [ALLOW Structural, skeletal or displayed formulae]	C_4H_9^+ $\text{C}_5\text{H}_7\text{O}^+$	2
<p>Penalise omission of + charge once only</p> <p>ALLOW any order of atoms if correct totals.</p>			

Question Number	Acceptable Answers	Reject	Mark
2(e)(i)		Circle around any other additional atoms	1

Question Number	Acceptable Answers	Reject	Mark
2(e)(ii)		Circle around any other additional atoms	1

Question Number	Acceptable Answers	Reject	Mark
2(f)(i)	 <p>Arrow from anywhere on the cyanide ion to the carbon of the carbonyl. Arrow to the O must come from the carbonyl bond (1)</p> <p>Formula of intermediate (1)</p> <p>Arrow from oxygen to H and from H-CN bond to CN (1)</p> <p>ALLOW arrow from O⁻ to H⁺ or to H₂O</p>	Starting from HCN/ CN ^{δ-} Single headed arrows	3

Question Number	Acceptable Answers	Reject	Mark
2(f)(ii)	<p>These marks are stand alone EITHER No</p> <p>First mark: Reaction site/carbonyl/aldehyde/molecule is planar (1)</p> <p>Second mark: Attack (equally likely) from both sides OR Attack (equally likely) from above and below (1)</p> <p>Third mark: (gives) racemic mixture/(gives) equal amounts of each isomer/(gives) equal amounts of each enantiomer (1) OR Yes Melongal has a chiral carbon atom (1) Correct identification of chiral centre (1) This chiral centre unaffected by reaction (1)</p>	<p>attack on a (planar) carbocation OR attack on a (planar) intermediate OR S_N1 OR S_N2 OR "planar product"</p> <p>Any/either direction or any/either angle</p>	3

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	Addition (1) Nucleophilic (1) Either order	SN1 SN2	2

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	<p>Hydrogen cyanide / HCN (1)</p> <p>Potassium cyanide / KCN/ sodium cyanide/ NaCN (1)</p> <p>OR</p> <p>Potassium cyanide / KCN (1) With hydrochloric acid / sulfuric acid (to generate HCN) (1)</p> <p>Ignore concentration of acids Mark for HCl etc is consequential on KCN</p> <p>OR</p> <p>Hydrogen cyanide / HCN (1) With sodium hydroxide / other base (to make cyanide ions) (1) Mark for NaOH etc is consequential on HCN</p>	<p>Just CN⁻</p> <p>Just CN⁻</p> <p>Just acid/ H⁺ any weak acid</p> <p>Just OH⁻</p>	2

Question Number	Acceptable Answers	Reject	Mark
<p>3 (a) (iii)</p>	<p>(1)</p> <p>(1)</p> <p>(3)</p> <p>Both arrows in first step of mechanism above correctly drawn (1)</p> <p>Correct intermediate with charge (1)</p> <p>Both arrows in second step with correct organic product (CN⁻ is not required) (1)</p> <p>Use of HCN for first step max 2 marks</p> <p>Allow omission of lone pair on CN⁻ and O⁻ Allow curly arrow from negative charge or elsewhere on cyanide ion</p> <p>Allow arrow from O⁻ in 2nd step to H⁺ (no other product or only one product) or H₂O (with OH⁻ formed)</p>	<p>C=O breaking before attack by CN⁻</p> <p>Arrows from atoms when they should be from bonds and vice versa</p>	<p>3</p>

Question Number	Acceptable Answers	Reject	Mark
*3(a) (iv)	<p>Attack (by nucleophile on the C) is from both sides (equally)/ above and below (at the planar reaction site in the aldehyde group) (1)</p> <p>So a mixture of two enantiomers/(optical)isomers in equal proportions forms OR racemic mixture forms (1)</p> <p>First and second marks are independent</p>	<p>Attack on intermediate in reaction mechanism is from both sides Attack from both ends/two angles</p> <p>Just "both enantiomers form"</p>	2

Question Number	Acceptable Answers	Reject	Mark
3 (b)	<p>Any named (aqueous) strong acid or its formula.</p> <p>Allow (aqueous) sodium hydroxide followed by named acid or formula</p> <p>Ignore references to concentration</p>	<p>Water</p> <p>H⁺</p> <p>Potassium dichromate + sulfuric acid</p> <p>Carboxylic acids</p>	1

Question Number	Acceptable Answers	Reject	Mark
3 (c) (i)	2-hydroxypropanoic acid	<p>2-hydroxylpropanoic acid</p> <p>2-hydroxopropanoic acid</p> <p>2-hydroxypropan-1-oic acid</p>	1

Question Number	Acceptable Answers	Reject	Mark
3 (c) (ii)	$\begin{array}{c} \text{CH}_3 \quad \quad \text{CH}_3 \\ \quad \quad \\ -\text{C}-\text{C}-\text{O}-\text{C}-\text{C}-\text{O}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array}$ <p>OR</p> $\begin{array}{c} \text{CH}_3 \quad \quad \text{CH}_3 \\ \quad \quad \\ -\text{O}-\text{C}-\text{C}-\text{O}-\text{C}-\text{C}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array}$ <p>All bonds in ester link must be shown More than 2 units may be shown but structure shown should be a repeat unit Ignore brackets/n</p>	<p>A dimer</p> <p>Missing H atoms</p> <p>Missing bonds at ends</p>	1

Question Number	Acceptable Answers	Reject	Mark
3 (c) (iii)	<p>Ester (link/bond) in PLA can be hydrolysed/broken down (by enzymes) OR Ester (link/bond) in PLA can be broken down</p>	Just "it can be hydrolysed"	1

Question Number	Acceptable Answers	Reject	Mark
3 (c) (iv)	<p>Ethene is (from crude oil so) non-renewable/ milk is from a renewable source/ energy required to make ethene is high/ high temperatures needed to make ethene/ energy requirements for process from sour milk less/ process from milk doesn't use toxic chemicals / process from milk doesn't use cyanide</p> <p>Allow process from ethene requires many steps so expensive/so loss of material occurs at each step /so more reagents needed</p> <p>Ignore references to cost, unless answer gives a reason for lower cost.</p>	<p>Milk is more readily available Greater atom economy</p> <p>No other chemicals needed in process from milk</p> <p>Just "process from ethene requires many steps"</p> <p>Just "cheaper"</p>	1