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# **GCE A LEVEL MARKING SCHEME**

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**SUMMER 2022**

**A LEVEL  
CHEMISTRY – UNIT 4  
1410U40-1**

## **INTRODUCTION**

This marking scheme was used by WJEC for the 2022 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

**GCE A LEVEL CHEMISTRY**  
**UNIT 4 – ORGANIC CHEMISTRY AND ANALYSIS**  
**SUMMER 2022 MARK SCHEME**

**GENERAL INSTRUCTIONS**

Extended response questions

A level of response mark scheme is applied. The complete response should be read in order to establish the most appropriate band. Award the higher mark if there is a good match with content and communication criteria. Award the lower mark if either content or communication barely meets the criteria.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

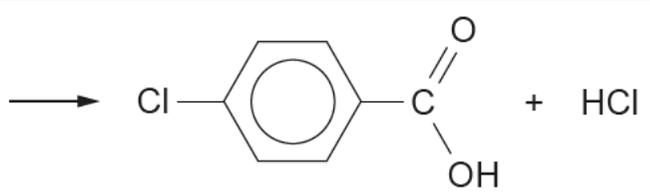
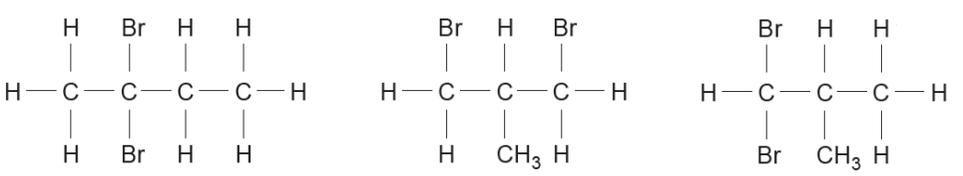
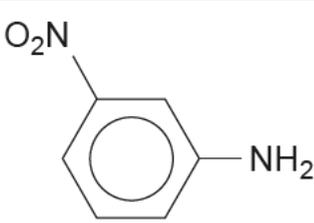
Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only  
ecf = error carried forward  
bod = benefit of doubt

Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

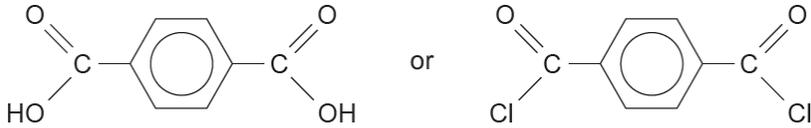
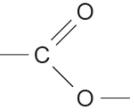
Section A

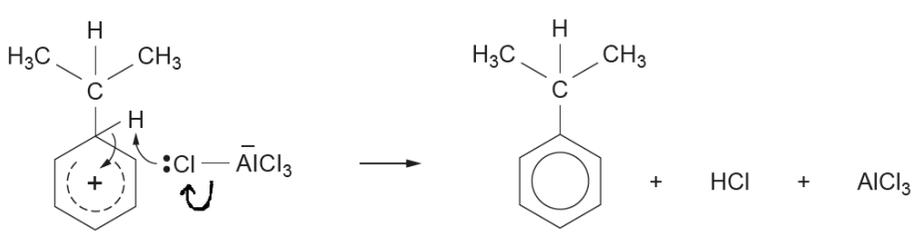
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1				C=C at 1620-1670 cm <sup>-1</sup> will identify pent-1-ene		1		1		
2				but-1-ene / but-2-ene / methylpropene correct names are needed here		1		1		1
3						1		1		
4				award (1) for any of following 			1	1		
5						1		1		

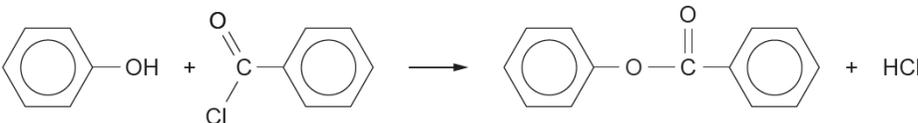
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		nucleophilic addition	1			1		
	(b)				1		1		
7	(a)	(i)	$\text{CH}_3\text{---CH}_2\text{---CH}_2\text{---C}\begin{matrix} \text{O} \\ \parallel \\ \text{OH} \end{matrix}$ or $\begin{matrix} \text{H}_3\text{C} \\ \diagdown \\ \text{H---C} \\ \diagup \\ \text{H}_3\text{C} \end{matrix}\text{---C}\begin{matrix} \text{O} \\ \parallel \\ \text{OH} \end{matrix}$	1			1		1
		(ii)	$\begin{matrix} \text{O} & \text{OH} \\ \parallel &   \\ \text{CH}_3\text{---C} & \text{---C---CH}_3 \\ &   \\ & \text{H} \end{matrix}$			1	1		
	(b)		all the protons are in <u>equivalent environments</u> and the spectrum will consist of <u>one singlet/peak</u>			1	1		
<b>Section A total</b>				<b>2</b>	<b>5</b>	<b>3</b>	<b>10</b>	<b>0</b>	<b>2</b>

## Section B

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)	nickel / platinum	1			1		
		(ii)	I cyclohexanol contains an O—H bond at 3200 to 3550 cm <sup>-1</sup> / cyclohexanol contains a C—O bond at 1000 to 1300 cm <sup>-1</sup> (1)  cyclohexanone contains a C=O bond at 1650 to 1750 cm <sup>-1</sup> (1)  award (1) for partial answer to both points e.g. cyclohexanone gives peak at 1700 and cyclohexanol gives peak at 3300	1			2		
			II cyclohexanol, C <sub>6</sub> H <sub>11</sub> OH  $M_r = 100.12$ % oxygen = $\frac{16 \times 100}{100.12} = 15.98$ (1)  cyclohexanone, C <sub>6</sub> H <sub>10</sub> O  $M_r = 98.10$ % oxygen = $\frac{16 \times 100}{98.10} = 16.31$ (1)  these two percentage figures are too close for accurate determination of the proportions present (1)		1		3		
			III % by volume = $\frac{49 \times 100}{84} = 58$	1			1		
		(iii)	acidified dichromate / Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> , H <sup>+</sup> acidified manganate(VII) / MnO <sub>4</sub> <sup>-</sup> , H <sup>+</sup>	1			1		1

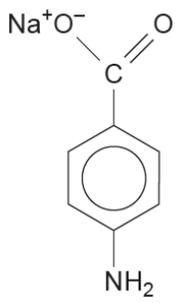
Question		Marking details		Marks available							
				AO1	AO2	AO3	Total	Maths	Prac		
	(b)		 <p>(1)</p> <p>(1)</p> 								
	(c)	(i)	<p>the polymer is made from an alkene / the monomer has a C=C bond / no additional compound is formed (when polymerisation occurs) (1)</p> <p>award (1) for any of following</p> <p>a polyester contains a  group in the chain</p> <p>there is no ester <u>linkage</u></p> <p>a polyester is made from an alcohol and a carboxylic acid / acid chloride</p>								
		(ii)	<p>mass of polymer used = <math>\frac{150}{300} = 0.5 \text{ g}</math> (1)</p> <p><math>M_r = \frac{0.50}{4.0 \times 10^{-6}} = 125\,000</math> (1)</p>								
<b>Question 8 total</b>				<b>5</b>	<b>5</b>	<b>4</b>	<b>14</b>	<b>1</b>	<b>1</b>		

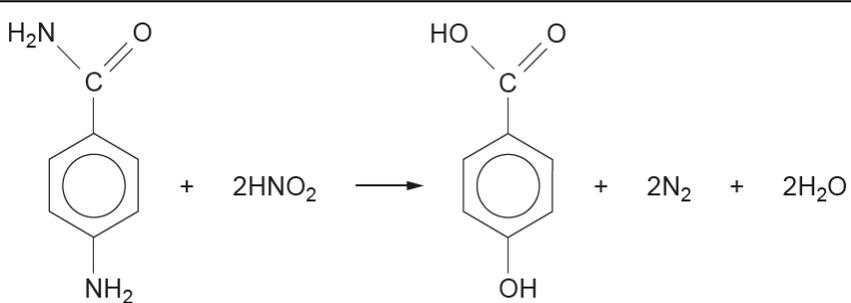
Question				Marking details	Marks available									
					AO1	AO2	AO3	Total	Maths	Prac				
9	(a)	(i)		(concentrated) nitric acid and (concentrated) sulfuric acid	1			1						
		(ii)		tin/iron and (concentrated) hydrochloric acid	1			1						
	(iii)		separation problems – the boiling temperature of the three isomers are too close together  accept other sensible answers			1	1							
	(iv)		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Reagent</td> <td style="width: 33%;">FeCl<sub>3</sub></td> <td style="width: 33%;">NaHCO<sub>3</sub></td> </tr> <tr> <td>Observation</td> <td>purple colour</td> <td>no change</td> </tr> </table>	Reagent	FeCl <sub>3</sub>	NaHCO <sub>3</sub>	Observation	purple colour	no change	1	1		2	
Reagent	FeCl <sub>3</sub>	NaHCO <sub>3</sub>												
Observation	purple colour	no change												
	(b)			→ 5C + 2CO + N <sub>2</sub> + 3H <sub>2</sub> O		1		1						
	(c)			 <p>award (1) for curly arrows – must have arrow into benzene ring and one other award (1) for all three products</p>	1	1		2						

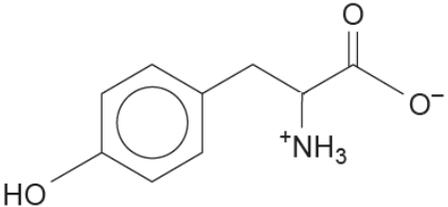
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
(d)	(i)		$n(\text{benzene}) = \frac{234 \times 1000}{78} = 3000$ (1) $n(\text{phenol}) \text{ at } 86\% \text{ yield} = \frac{3000 \times 86}{100} = 2580$ $\text{mass of phenol} = \frac{2580 \times 94}{1000} = 243 \text{ kg}$ (1)		1		2	1	
	(ii)		a species with an unpaired electron	1			1		
	(iii)		award (1) for any radical e.g. <ul style="list-style-type: none"> <li>•CH<sub>3</sub></li> <li>•Cl</li> <li>•CH<sub>2</sub>Cl</li> </ul>		1		1		1
(e)			award (1) for either of following  solution remains yellow / orange no more white precipitate is formed			1	1		
(f)	(i)				1		1		
	(ii)		CH <sub>3</sub> COCl will react (preferentially) with the <u>NaOH / water</u>			1	1		1
	(iii)		pyridine acts as a base / removes H <sup>+</sup> (1)  as its nitrogen atom has a lone pair (of electrons) (1)			2	2		
<b>Question 9 total</b>				<b>5</b>	<b>7</b>	<b>5</b>	<b>17</b>	<b>1</b>	<b>4</b>

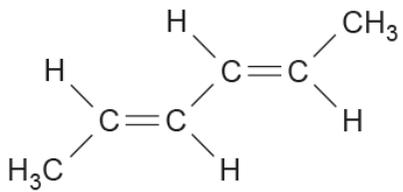
Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
10	(a)	<p><b>Indicative content</b></p> <p>molar mass is <math>72 \text{ g mol}^{-1}</math> of which 50.0% is carbon  <math>\Rightarrow</math> each molecule of compound <b>G</b> must contain 3 carbon atoms</p> <p>this leaves a mass of 36 <math>\Rightarrow</math> must be 2 oxygen atoms and 4 hydrogen atoms as 1 oxygen atom and 20 hydrogen atoms is not feasible</p> <p>molecular formula is <math>\text{C}_3\text{H}_4\text{O}_2</math></p> <p>it reacts with Tollens reagent <math>\Rightarrow</math> must be an aldehyde / have the CHO group</p> <p>it gives a yellow solid with alkaline iodine</p> <p><math>\Rightarrow</math> must have a <math>\text{CH}_3-\text{C}(=\text{O})</math> group or a <math>\text{CH}_3-\text{C}(\text{OH})(\text{H})</math> group</p> <p>only 2 hydrogen environments, <math>\text{CH}_3</math> group (at <math>\sim 2.2</math>) and CHO group (at <math>\sim 9.4</math>)</p> <p><math>\Rightarrow</math> suggests <math>\text{CH}_3-\text{C}(=\text{O})-\text{C}(=\text{O})-\text{H}</math></p> <p>reduction of this compound gives a diol with molar mass <math>76 \text{ g mol}^{-1}</math></p> $\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{OH} \\   \quad   \\ \text{OH} \quad \text{H} \end{array} \quad \Rightarrow \text{confirms above structure}$	2	2	2	6		2

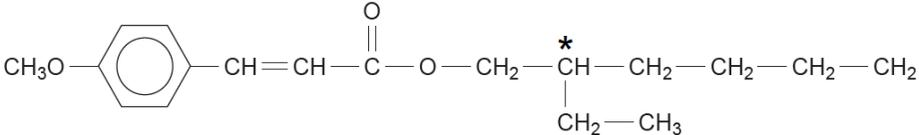
Question	Marking details
	<p><b>5-6 marks</b>  All the information has been used including the NMR spectrum; correct structure given  <i>The candidate constructs a relevant, coherent and logically structured account including key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary is used accurately throughout.</i></p> <p><b>3-4 marks</b>  Most of the information has been used correctly but there are some omissions; some correct features in the structure  <i>The candidate constructs a coherent account including many of the key elements of the indicative content. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.</i></p> <p><b>1-2 marks</b>  Some of the information has been used but there are many omissions  <i>The candidate attempts to link relevant points from the indicative content. Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.</i></p> <p><b>0 marks</b>  <i>The candidate does not make any attempt or give an answer worthy of credit.</i></p>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			$E_1 \times \lambda_1 = E_2 \times \lambda_2$ (1) $\lambda_2 = \frac{E_1 \times \lambda_1}{E_2} = 267 \text{ kJ mol}^{-1}$ (1) alternative method constant = $E \times \lambda = 1.2 \times 10^5$ (1) $E = \frac{1.2 \times 10^5}{450} = 267 \text{ kJ mol}^{-1}$ (1)			1	2	1	
	(c)	(i)	I	 <p style="text-align: center;">accept if Na<sup>+</sup> not included</p>			1	1		
			II	the attacking reagent / OH <sup>-</sup> is a nucleophile(1) lone pair on N becomes part of delocalised system / C—N bond is stronger when directly attached to ring (1)		2		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		 <p>correct formulae (1) balancing (1)</p>				2		
<b>Question 10 total</b>				<b>2</b>	<b>7</b>	<b>4</b>	<b>13</b>	<b>1</b>	<b>2</b>	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)	(i)		chromatogram drawn correctly with spot at 6 cm mark		1		1		1
		(ii)			1			1		
		(iii)		the polar structure / OH group is a small part of the overall molecule so hydrogen bonding is at a 'minimum'			1	1		
		(iv)	I	<p>24500 cm<sup>3</sup> of nitrogen from 181 g of tyrosine (1)</p> <p>1 cm<sup>3</sup> of nitrogen from <math>\frac{181}{24500}</math> g of tyrosine</p> <p>147 cm<sup>3</sup> of nitrogen from <math>147 \times \frac{181}{24500} = 1.09</math> g(1)</p> <p>accept alternative methods</p> <p>e.g. <math>n = \frac{pV}{RT} = 0.006</math> (1)</p> <p>mass = 0.006 × 181 = 1.09g (1)</p> <p>e.g. 1 mol tyrosine gives 1 mol N<sub>2</sub></p> <p><math>n(\text{N}_2) = \frac{1.09}{181} = 6 \times 10^{-3}</math> (1)</p> <p><math>V = \frac{nRT}{p} = 147\text{cm}^3</math> (1)</p>		2		2	1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
			II	award (1) for any of following not all the nitrogen was collected impure sample of tyrosine erroneous starting mass incomplete reaction			1	1		1
	(b)	(i)		$M_r$ of calcium butane-1,4-dioate = 156 (1) atom economy = $\frac{156}{(74 + 180)} \times 100 = 61$ (1)	1	1		2		
		(ii)		moles of calcium butane-1,4-dioate = $\frac{41.2}{156} = 0.264$ moles of $H_2SO_4$ needed = 0.264 (1) volume of $H_2SO_4$ needed = $\frac{0.264 \times 1000}{2.5} = 106 \text{ cm}^3$ (1)		2		2	1	
	(c)			 <p>there are 3 peaks (1)</p> <p>award (1) for recognising the equivalence of three pairs of C atoms can be labelled on structure or in statement e.g. both <math>CH_3</math> carbon atoms are equivalent, both 'end' carbon atoms of double bonds are equivalent and both 'internal' carbon atoms of double bonds are equivalent</p>		1		2		
<b>Question 11 total</b>					<b>2</b>	<b>7</b>	<b>3</b>	<b>12</b>	<b>2</b>	<b>2</b>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)	(i)		compound <b>A</b> does not absorb effectively in the UVA region			1	1		
		(ii)		$C_{10}H_{10}O_3$		1		1		
		(iii)	I	structural isomerism is concerned with the position of atoms within a molecule (1)  stereoisomerism is concerned with the positions that the atoms take up in space (1)  neutral answers – reference to mirror images, chiral centres, E/Z	2			2		
			II		1			1		
			III	it does not rotate the plane of plane polarised light		1		1		
			IV	 <i>E</i> - form <i>Z</i> - form correct formulae (1) labelling (1)	2			2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)		electrophilic addition	1			1		
		(ii)		3 mol of I <sub>2</sub> needed for 1 mol of the unsaturated oil moles of unsaturated oil = $\frac{0.0128}{3} = 0.00427$ (1) mass of unsaturated oil = 0.00427 × 885 = 3.78 g percentage of unsaturated oil = $\frac{3.78}{8.41} \times 100 = 45\%$ (1)		2		2	1	
		(iii)		3 NaOH (1) 3 C <sub>17</sub> H <sub>33</sub> COONa (1)		1	1	2		
		(iv)		propane-1,2,3-triol		1		1		
<b>Question 12 total</b>					<b>6</b>	<b>6</b>	<b>2</b>	<b>14</b>	<b>1</b>	<b>0</b>

## UNIT 4: ORGANIC CHEMISTRY AND ANALYSIS

### SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
<b>Section A</b>	<b>2</b>	<b>5</b>	<b>3</b>	<b>10</b>	<b>0</b>	<b>2</b>
<b>8</b>	<b>5</b>	<b>5</b>	<b>4</b>	<b>14</b>	<b>1</b>	<b>1</b>
<b>9</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>17</b>	<b>1</b>	<b>4</b>
<b>10</b>	<b>2</b>	<b>7</b>	<b>4</b>	<b>13</b>	<b>1</b>	<b>2</b>
<b>11</b>	<b>2</b>	<b>7</b>	<b>3</b>	<b>12</b>	<b>2</b>	<b>2</b>
<b>12</b>	<b>6</b>	<b>6</b>	<b>2</b>	<b>14</b>	<b>1</b>	<b>0</b>
<b>Totals</b>	<b>22</b>	<b>37</b>	<b>21</b>	<b>80</b>	<b>6</b>	<b>11</b>