GCE A LEVEL MARKING SCHEME

AUTUMN 2021

A LEVEL
CHEMISTRY - COMPONENT 2
A410U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2021 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.

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

AUTUMN 2021 MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark, apart from extended response questions where a level of response mark scheme is applied.

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

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

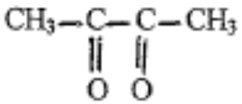
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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

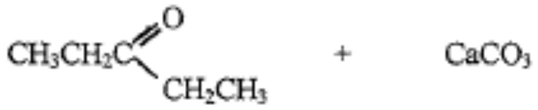
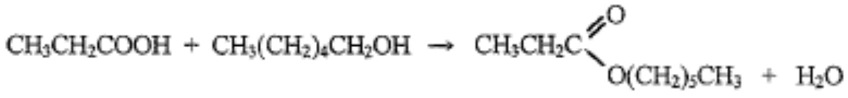
Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

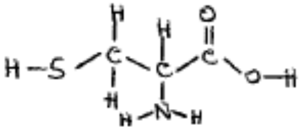
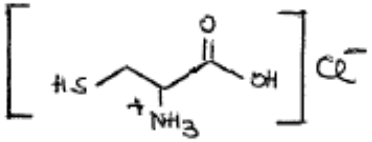
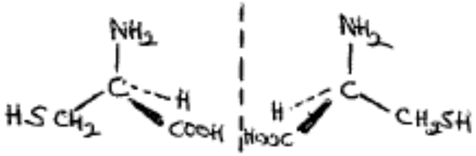
Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			CH_2	1			1		
	(b)	(i)		80		1		1		
		(ii)		peak **C** **B** is methylcyclohexane and **C** will have a longer retention time than **B,** as its M_r is greater than **B**, but not as great as propylcyclohexane which is peak **D** other acceptable answers to be discussed at the conference			1	1		
2	*(a)*			1:1 reaction therefore 0.500 mol of Br_2 is needed (1) volume = $\frac{m}{d}$ = $\frac{159.8 \times 0.500}{3.16}$ = 25.3 (1)		1	1	2	1	
	(b)			the melting temperature is lower (and over a range)	1			1		1
3	*(a)*			yellow because the colour seen is the colour(s) not absorbed accept orange / red / other end of visible spectrum	1			1		
	(b)			Sn / Fe and concentrated HCl		1		1		1
	(c)	(i)		ethanoic anhydride / ethanoyl chloride / $(CH_3CO)_2O$ / CH_3COCl	1			1		
		(ii)		yellow / orange to colourless / white (precipitate)		1		1		1

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4				0.365 g of Ag from 0.774 g of salt						
				1 g of silver from $\frac{0.774}{0.365}$ g of salt						
				108 g / 1 mol of silver from $\frac{0.774}{0.365} \times 108$ = 229 g of salt				2		
				*M*_r of salt = 229 (1)		1			1	
				*M*_r of acid = 229 – 108 + 1 = 122 (1)			1			
5				 $CH_3-C(=O)-C(=O)-CH_3$ (1)	1					
				m/z of molecular ion is 86 (1)		1		3		
				award (1) for both of following fragments m/z 43 → CH_3CO^+ m/z 15 → CH_3^+			1			
				Section A total	**5**	**6**	**4**	**15**	**1**	**3**

Section B

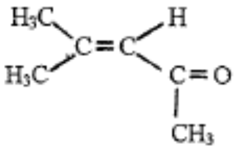
Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
6	*(a)*			 $CH_3CH_2C(=O)CH_2CH_3 + CaCO_3$		1		1		
	(b)	(i)		n($CaSO_4$) = $\frac{5.70}{136}$ = 0.0419 (1) 1:1 mol ratio therefore % purity of calcium propanoate $\frac{0.0419 \times 186}{8.38} \times 100$ (1) 93.0 (1) **must** be given to 3 sig figs	1	2		3	1	
		(ii)	I	separating / dropping funnel	1			1		1
			II	award (1) for any of following look up the densities and the less dense liquid is the top layer / more dense liquid is the bottom layer add a drop of hexan-1-ol / water to the mixture and see which layer it joins			1	1		1
		(iii)		 $CH_3CH_2COOH + CH_3(CH_2)_4CH_2OH \rightarrow CH_3CH_2C(=O)O(CH_2)_5CH_3 + H_2O$ balanced equation (1) structure of ester (1)		2		2		

Question				**Marking details**	**Marks available**					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(c)			solubility in 100g water at 100°C is 56g and at 0°C is 49g in 20g water ⇨ $\frac{56}{5}$ at 100°C and $\frac{49}{5}$ at 0°C (1) amount precipitated is $\frac{7}{5}$ = 1.4g (1)		2		2		
	(d)	(i)			1			1		
		(ii)					1	1		
		(iii)				1		1		
	(e)	(i)		$c = f\lambda$(1) $f = \frac{3.00\times10^{8}}{480\times10^{-9}}$ = 6.25 × 10^{14} (1)	1	1		2	2	

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>$\frac{absorption\ 2}{absorption\ 1} = \frac{concentration\ 2}{concentration\ 1}$ (1)
$concentration\ 2 = \frac{0.70 \times 5 \times 10^{-4}}{1.25} = 2.8 \times 10^{-4}$ (1)
credit other appropriate method</td><td></td><td>1</td><td>1</td><td>2</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 6 total</td><td>4</td><td>10</td><td>3</td><td>17</td><td>4</td><td>2</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*			award (1) for $NH_2(CH_2)_5COOH$ on left hand side and H_2O on right hand side **both** needed		1		1		
	(b)	(i)		5% conversion ⇨ total 120 mol of cyclohexanol / cyclohexanone but 2:1: ratio therefore 80 mol cyclohexanol (1) M_r(cyclohexanol) = 100.1 (1) mass of cyclohexanol = 100.1 × 80 = 8.01 (1) **must** be given in kg	1	1	1	3	1	
		(ii)	I	the N atom has a lone pair of electrons which attacks the relatively $\delta+$ carbon atom (of the carbonyl group)		1		1		
			II	as the reaction proceeds the intensity of the C=N at 1665cm^{-1} decreases O–H at ~3200 cm^{-1} decreases C=O at 1650-1750 cm^{-1} increases N–H at 3300-3500 cm^{-1} increases C–N at 1020-1250 cm^{-1} increases award (2) for all five award (1) for one absorption which decreases **and** one which increases			2	2		
			III	award (1) for any of following rearrangement reaction therefore M_r is unchanged both compounds have the same M_r atom economy is 100%			1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			award (1) each for any **two** of following availability / cost of catalyst temperature needed pressure needed - linked to cost or safety availability of starting materials percentage conversion other answers to be discussed at the conference	2			2		
	(d)	(i)		award (1) for either of following to prevent water / cyclohexanol from distilling over to only allow cyclohexene to distil over			1	1		1
		(ii)		to avoid a build-up of pressure / to allow air present in the apparatus to escape	1			1		1
		(iii)		water (1) some escapes from the mixture because its boiling temperature is not much higher than 90°C (1)		2		2		2
		(iv)		moles of cyclohexene = $\frac{10}{66} = 0.152$ percentage yield = $\frac{0.152 \times 100}{0.20} = 76$ accept 75		1		1		
		(v)		elimination of 1 mol of water from 2 mol of cyclohexanol			1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)		1:1 mole ratio for an addition reaction therefore 6.86g is the mass of of 0.070 mol (1) $M_r = \frac{6.86}{0.070} = 98$ ⇨ this fits $C_6H_{10}O$ (1)	1	1		2		
		(ii)	I	electrophilic addition	1			1		
			II	 addition of hydrogen across the C=C double bond gives the named compound / 4-methylpentan-2-one		1		1		
				Question 7 total	**6**	**8**	**6**	**20**	**1**	**4**

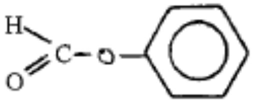
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	(i)		**Indicative content** 4.0 cm^3 of benzaldehyde used 3.6 cm^3 of phenylamine used suitable volume of ethanol (25-50 cm^3) / minimum volume health and safety considerations / risk assessment reference to stirring suitable size of apparatus use of dropping pipette / measuring cylinders	2	2	2	6		6
				5-6 marks Correct method with appropriate quantities of reactants and apparatus sizes *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.* **3-4 marks** Acceptable method with omission of some quantities of reactants and apparatus sizes *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.* **1-2 marks** Brief outline method with limited detail relating to reagents and apparatus *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*						

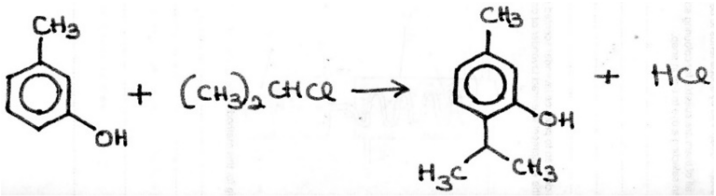
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td></td><td>(ii)</td><td>I</td><td>award (1) for either of following
operates at room temperature
quicker</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>II</td><td>award (1) for either of following
lower yield
problem of removing catalyst</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td><i>(b)</i></td><td></td><td></td><td>structure of the 2-isomer allows intramolecular forces / forces within each molecule to occur (1)

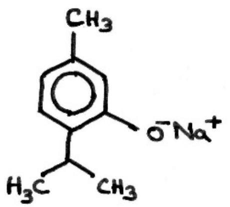
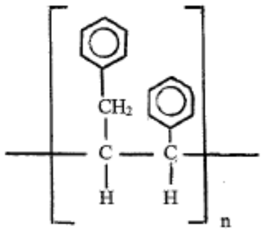
this reduces the tendency for intermolecular forces (1)

less energy is needed to separate the molecules into the liquid state giving a lower melting temperature (1)

structure of the 4-isomer does not enable intramolecular forces to occur in the same way so the tendency is for ‘more’ intermolecular forces and higher melting temperatures (1)</td><td></td><td>2</td><td>2</td><td>4</td><td></td><td></td></tr>
<tr><td></td><td><i>(c)</i></td><td>(i)</td><td></td><td><table>
<tr><th>Reagent</th><th>Benzoic acid</th><th>2-Hydroxybenzaldehyde</th></tr>
<tr><td>$NaHCO_3$</td><td>effervescence</td><td>no observation</td></tr>
<tr><td>I_2 / NaOH</td><td>no observation</td><td>no observation</td></tr>
<tr><td>$FeCl_3$</td><td></td><td>purple solution</td></tr>
</table>
award (1) for each correct column</td><td></td><td>2</td><td></td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>$(C_6H_5COO)_3Fe$</td><td></td><td></td><td>1</td><td>1</td><td></td><td></td></tr>
</table>

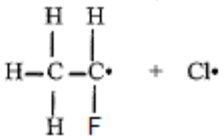
Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(d)			 (1)		1		2		
				award (1) for either of following contains an aldehyde / CHO group the ester is a reducing agent		1				
				Question 8 total	**4**	**8**	**5**	**17**	**0**	**8**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*	(i)		$5.5 \times \frac{12}{100} = 0.66$ g in 100 g of oil (1) 0.66 × 10^{-2} g in 1 g of oil 6.6 mg g^{-1} (1) **must** be given to 2 sig figs		2		2	1	
		(ii)		award (1) for any of following ethanol is renewable CH_2Cl_2 is not renewable / CH_2Cl_2 made from oil CH_2Cl_2 damages the ozone layer other answers to be discussed at the conference		1		1		
		(iii)		diazonium compounds react with phenols to give coloured **azo dyes** (1) mention of chromophores / –N=N– (1)			2	2		
		(iv)		 (1) catalyst $AlCl_3$ / $FeCl_3$ (1)	1	1		2		

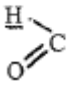
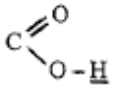
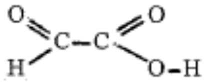
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(v)	I	for thymol to dissolve in water **hydrogen bonding** must be possible (1) the —OH group (which could form hydrogen bonds with water) is only a small part of a much larger molecule (1)	1	1		2		
			II				1	1		
	(b)	(i)		alcoholic KOH / NaOH		1		1		1
		(ii)		award (1) for either of following both carbon atoms involved in the C=C bond are bonded to two different atoms / groups there is no rotation about the C=C bond	1			1		
		(iii)			1			1		

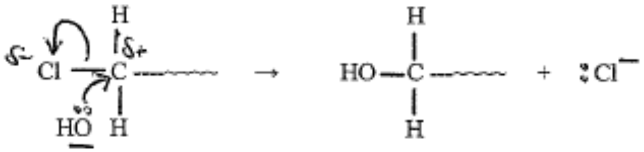
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)	I	potassium cyanide / KCN	1			1		
			II	reduction	1			1		
			III	at 273K and 1 atm the molar volume is 22.4dm^3 at 317K and 1 atm the molar volume is $\frac{22.4 \times 317}{273}$ = 26.0 dm^3 (1) 1:1 mole ratio ⇨ 26000 cm^3 from 225 g of compound **T** 1 cm^3 from $\frac{225}{26000}$ g 200 cm^3 from $\frac{225 \times 200}{26000}$ = 1.73 g (1) accept answers based on pV = nRT correct working (1) correct final fraction (1)		1 1		2	2	
				Question 9 total	**6**	**8**	**3**	**17**	**3**	**1**

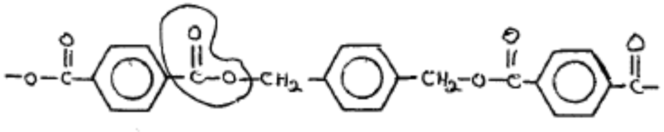
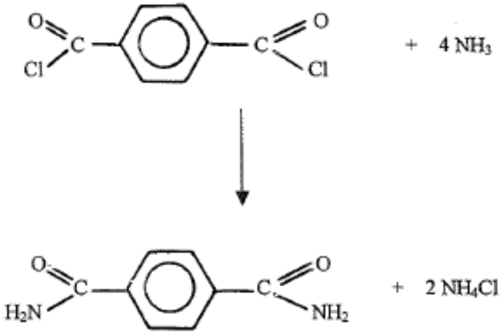
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*	(i)		$\frac{140}{(6\times 30)+(4\times 17)}\times 100$ = 56 award (2) for correct answer if answer incorrect award (1) for three correct M_r values $M_r[(CH_2)_6N]$ = 140 $M_r(CH_2O)$ = 30 $M_r(NH_3)$ = 17		2		2	1	
		(ii)		all carbon atoms are in same environment and all hydrogen protons are in the same environment			1	1		
		(iii)		tertiary - nitrogen atom bonded directly to three carbon atoms (1) base - nitrogen atom has lone pair (which it can donate) (1)	1		1	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Indicative content** **Reaction 1** - the C–Cl bond is weaker than the C–F bond and should be broken in preference therefore  accept other sensible answers **Reaction 2** - aromatic rings are not susceptible to attack by nucleophiles such as OH^- so no reaction occurs accept other sensible answers **Reaction 3** - $Br\delta^-$ is not attacked by the π-electron cloud - $H\delta^+$ is attacked forming carbocation and bromide ion - the product is correct / 2-bromopropane formed preferentially accept other sensible answers **Reaction 4** - carboxylic acids are not reduced by $NaBH_4$ - $LiAlH_4$ should be used	2	2	2	6		

Question				Marking details
				5-6 marks Each reaction considered, errors identified and suitable corrections suggested *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.* **3-4 marks** Most of the reactions considered, some errors identified and some suitable corrections suggested *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.* **1-2 marks** Some of the reactions considered, attempt to identify errors *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(c)	(i)		M_r(AgCl) = 143.5 143.5g AgCl contains 35.5 g Cl 1g AgCl contains $\frac{35.5}{143.5}$ g Cl 8.83g AgCl contains $\frac{35.5}{143.5} \times 8.83$ = 2.184 g Cl (1) percentage Cl in the sample = $\frac{2.184}{4.75} \times 100$ = 46.0 (1)		2		2	1	
		(ii)		59% chloroethanoic acid 41% dichloroethanoic acid **both** needed	1			1		
	(d)			turns UI paper red ⇨ carboxylic acid (1) two of the three oxygen atoms must be in the acid group (1) two ^{13}C NMR signals ⇨ one carbon atom in an environment other than acid group (1) M_r is 74 but acid group COOH has M_r 45 ⇨ remainder is 29 must be one carbon, one oxygen and one hydrogen (1) ^{1}H NMR suggests  and  (1) structure of **W** must be  (1)	2	2	2	6		1
				Question 10 total	**6**	**8**	**6**	**20**	**2**	**1**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*			signal at 2.30 ppm due to (side-chain) alkyl protons and signal at 7.05 ppm due to aromatic protons (1) both signals are singlets so alkyl protons are all equivalent and aromatic protons are all equivalent (1) peak heights of 6 (aliphatic / methyl) and 4 (aromatic) fit the structure of 1,4-dimethylbenzene (1)		3		3		
	(b)			1:1 mole ratio ⇨ 0.240 mol of product expected (1) increase in mass = 0.240 × (175 – 106) = 16.6 (1)		2		2	1	
	(c)			 correct curly arrows (1) relevant lone pairs (1) partial / full charges (1)	1	2		3		
	(d)			alkaline potassium manganate(VII) / $KMnO_4$	1			1		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)				1		1		
		(ii)		ring drawn on any ester linkage in repeating section in part (i) e.g. as shown	1			1		
	(f)	(i)		award (1) for any of following phosphorus(V) chloride / phosphorus pentachloride / PCl_5 phosphorus(III)chloride / PCl_3 thionyl chloride / $SOCl_2$	1			1		1
		(ii)		 correct formulae (1) balanced equation (1)		1	1	2		
				Question 11 total	**4**	**9**	**1**	**14**	**1**	**2**

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	5	6	4	15	1	3
6	4	10	3	17	4	2
7	6	8	6	20	1	4
8	4	8	5	17	0	8
9	6	8	3	17	3	1
10	6	8	6	20	2	1
11	4	9	1	14	1	2
Totals	35	57	28	120	12	21