GCE A LEVEL MARKING SCHEME

SUMMER 2022

A LEVEL
CHEMISTRY – COMPONENT 2
A410U20-1

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

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMER 2022 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.

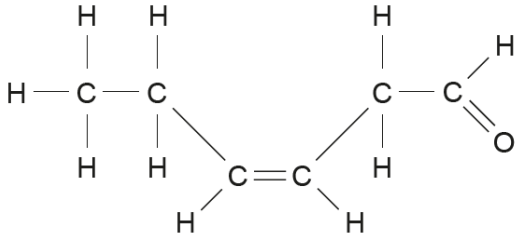
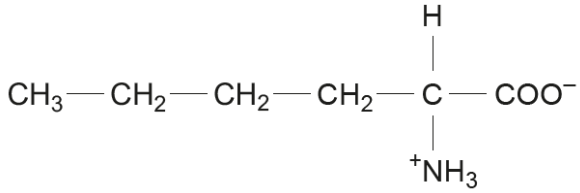
Marking abbreviations

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)				1			1		
	(b)	(i)		M_r ($C_6H_{10}O$) = 72.0 + 10.1 + 16.0 = 98.1 (1) percentage oxygen = $\frac{16.0}{98.1}$ × 100 = 16.3 (1)		2		2		
		(ii)		add aqueous bromine – decolourised			1	1		1
2	(a)				1			1		
	(b)			award (1) for either of following run the chromatogram again using a different solvent run a two-way chromatogram using two different solvents	1			1		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	(a)			accept any value in the range 228-232 °C		1		1		
	(b)			award (1) for either of following if the effect was a constant factor then the graph would be a straight line the graph is a curve showing this factor is not constant			1	1		1
	(c)			$\frac{92.6}{(92.1 + [2 \times 36.5] + 40)} \times 100 = 45.1$		1		1		
	(d)	(i)		award (1) each for any **two** of following (or other sensible suggestions) • yield • temperature / energy considerations • availability of catalyst / starting material • method of separation • batch or continuous process • reaction rate • atom economy • toxic co-products	2			2		
		(ii)		C=O which absorbs in the range 1650-1750 cm^{-1}	1			1		
4				award (1) for each correct reagent reagent **A** HCl / hydrogen chloride reagent **B** KCN / potassium cyanide reagent **C** $LiAlH_4$ / lithium tetrahydridoaluminate(III) H_2 with Ni catalyst	3			3		
				Section A total	**9**	**4**	**2**	**15**	**0**	**3**

Section B

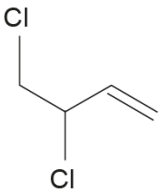
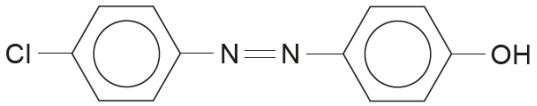
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>5</td><td>(a)</td><td>(i)</td><td></td><td>both carbon atoms in the C=C group have two different groups attached to them (1)

there is no free rotation about the double bond (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td><table><tr><th>Group</th><th>Chemical shift δ/ppm</th><th>Splitting pattern</th></tr><tr><td>ClCH₂</td><td>3.1-4.3</td><td>doublet</td></tr><tr><td>—HC=C</td><td>4.5-6.3</td><td>triplet</td></tr></table>
award (2) for all four correct
award (1) for any two correct</td><td></td><td>1</td><td>1</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td></td><td>award (1) for any working leading to fragment below e.g.

ClCH₂ 49/51
CH=CH 26
CH₂Cl 49/51

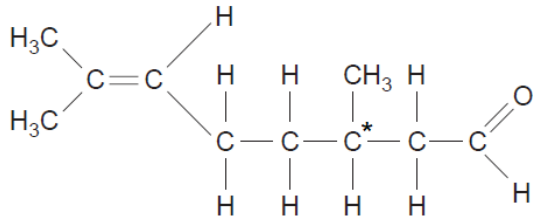
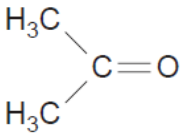
award (1) for $CH_2{}^{35}Cl—CH=CH^+$ as signal at 75

must make reference to ^{35}Cl isotope
do not penalise missing positive charge</td><td></td><td>1</td><td>1</td><td>2</td><td></td><td></td></tr>
</table>

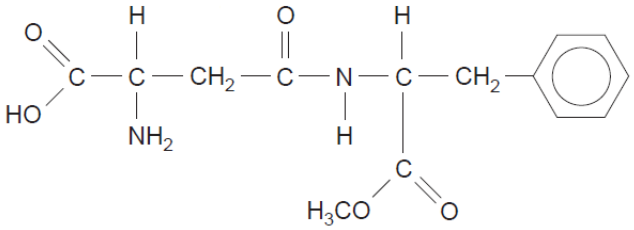
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)	I				1	1		
			II	<u>alcoholic</u> NaOH		1		1		
			III	an atom or molecule having an unpaired electron (1) award (1) for any radical e.g. •Cl / •CH_3	1	1		2		
	(b)	(i)		the aliphatic C—Cl bond is susceptible to nucleophilic substitution (as it is polarised $C^{\delta+}$—$Cl^{\delta-}$) (1) the aryl C—Cl bond is not susceptible to nucleophilic substitution as the C—Cl bond is stronger than the alkyl C—Cl bond (owing to lone pair delocalisation into the benzene ring) (1)		2				
		(ii)	I	5-10°C	1			1		1
			II			1		1		
			III	8.65×10^{14} (2) if answer incorrect award (1) for $c = f\lambda$ or $f = \frac{c}{\lambda}$	1	1		2	1	
				Question 5 total	**5**	**8**	**3**	**16**	**1**	**1**

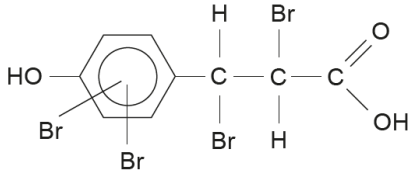
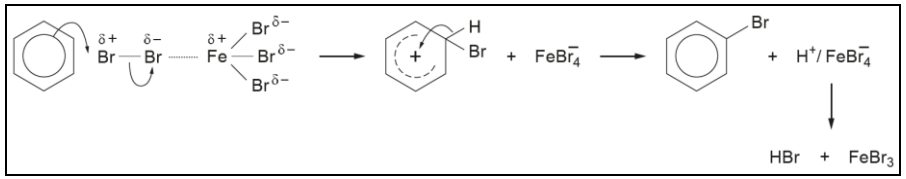
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)	(i)		0.0500 mol of ammonia from 0.0500 mol of benzamide M_r of benzamide = 121 mass of pure benzamide = 121 × 0.0500 = 6.05g (1) purity of benzamide = $\frac{6.05}{6.30} \times 100 = 96.0\%$ (1)	1	1		2	1	
		(ii)		award (1) for any of following dry at temperature lower than 100°C dry on a window sill / in a dessicator		1		1		1
	(b)	(i)		163		1		1	1	
		(ii)		'M_r' → 163 – (12 + 16 + 14 + 1 + 72 + 5) = 43		1		1		
		(iii)		C_3H_7		1		1		
		(iv)		$(CH_3)_2CH$ (1) award (1) for sensible explanation e.g. there are 6 equivalent protons protons are in 6:1 ratio there are (only) two proton environments		1	1	2		
	(c)	(i)		C_3H_4N		1		1		
		(ii)		where a small molecule / HCl / H_2O is eliminated	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)	I	alkaline potassium manganate(VII) / MnO_4^- , OH^-	1			1		1
			II	award (1) for any of following $SOCl_2$ / thionyl chloride PCl_3 / phosphorus trichloride PCl_5 / phosphorus pentachloride	1			1		1
		(iv)		award (1) for any of following heat to a higher temperature use NaOH of a higher concentration smaller particle size use a catalyst neutral answer – higher pressure	1			1		1
	(d)	(i)		moles of urea = $\frac{5 \times 480}{60}$ = 40 moles of NO_2 reacting = 60 (1) mass of NO_2 removed = 60 × 46 = 2.76 / 2.8 kg (1)		1	1	2	1	
		(ii)		CO_2 is produced which is a greenhouse gas / contributes to global warming	1			1		
				Question 6 total	**6**	**8**	**2**	**16**	**3**	**4**

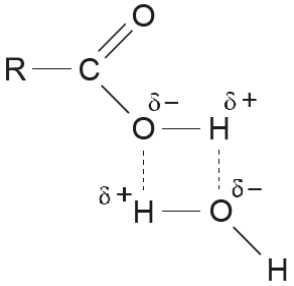
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)	(i)		$\frac{36}{75} \times 100 = 48\%$	1			1		
		(ii)			1			1		
		(iii)		molecular formula of compound **E** → C_3H_6O (1)  (1) accept CH_3CH_2CHO / $CH_3CH{=}CH(OH)$ / $CH_2{=}CHCH_2OH$			2	2		
		(iv)		1 mol geraniol reacts with 2 mol bromine ⇨ 0.020 mol geraniol reacts with 0.040 mol bromine mass of bromine = 0.040 × 159.8 = 6.4 g (1) volume of bromine = $\frac{6.4}{3.2}$ = 2.0 cm^3 (1)		2		2	1	
	(b)	(i)		boiling at a constant temperature without loss of material	1			1		1
		(ii)		no longer two layers / one layer / no longer cloudy			1	1		1

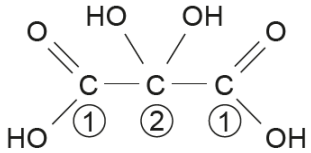
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		wash with water (to remove traces of soluble impurities)		1		1		1
		(iv)		at 14°C solubility is 0.7g /100g H_2O → 0.35g / 50g H_2O mass precipitated is 8.0 – 0.35 = 7.65 g		1		1		
	(c)	(i)		$LiAlH_4$	1			1		
		(ii)			1			1		
		(iii)		dehydration accept elimination			1	1		
	(d)			add $NaHCO_3$ / Na_2CO_3 (1) effervescence with the most acidic (1)		2		2		2
				Question 7 total	**5**	**6**	**4**	**15**	**1**	**5**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)						1	1		
	(b)			moles of aspartame = $\frac{73.5}{294}$ = 0.250 (1) therefore 0.750 mol of NaOH needed volume = $\frac{0.750}{\frac{4.00}{1000}}$ = 187.5 cm^3 (1)	1	1		2	1	
	(c)	(i)		award (1) for any of following HNO_2 / HONO / nitric(III) acid / nitrous acid $NaNO_2$ and HCl / sodium nitrate(III) and hydrochloric acid		1		1		1
		(ii)		hydrogen is removed		1		1		
		(iii)		award (1) for correct structure of any other aldehyde		1		1		1
	(d)	(i)		magnesium / zinc		1		1		1
		(ii)		purple coloration / solution	1			1		1

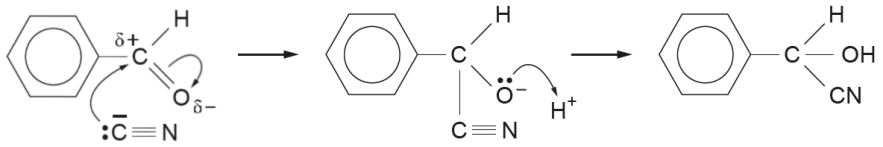
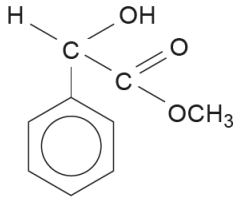
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		award (1) for reference to mass of 9 carbon atoms and 3 oxygen atoms in working e.g. 108 + 48 = 156 award (1) for reference to 4 bromine atoms in working award (1) for reference to 6 hydrogen atoms in working (2nd and 3rd marks can be awarded for molecular formula $C_9H_6Br_4O_3$)  (1)			4	4	2	
	(e)			**Indicative content** • delocalisation / need to retain stability • π electron cloud – attractive to electrophiles • substitution by bromine ensures retention of stability • polarisation of bromine molecule • $FeBr_3$ catalyst to aid polarisation  features in mechanism • correct curly arrows • polarisation / partial charges • correct intermediates • products correct • $FeBr_3$ regenerated	2	4		6		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Good description of the structure of benzene; detailed explanation of bromination including key stages in the mechanism *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** Attempt at description of the structure of benzene; attempt at description of bromination with aspects of the mechanism *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** Basic reference to the structure of benzene; some details of bromination reaction *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 8 total	**4**	**9**	**5**	**18**	**3**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		octanoic acid	1			1		
		(ii)		the solubility (largely) depends on hydrogen bonding (1) solubility decreases because the COOH / OH group forms an increasingly small part of the molecule / increasing van der Waals forces are weaker than decreasing hydrogen bonding forces (1)  (1)	2	1		3		
	(b)	(i)		$C_{12}H_{22}O_{11}$ + **18** [O] → **6** $(COOH)_2$ + **5** H_2O		1		1		
		(ii)	I	it will be lower and over a range of temperature	1			1		1
			II	ethanedioic acid dihydrate will give only one signal as both carbon atoms are equivalent (1) mesoxalic acid will give two signals as there are two different carbon environments (1)	1	1		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				credit possible for details shown in formula e.g.  award (1) if correct number of signals given for both but inadequate explanation						
	(c)	(i)		mass of diethyl ethanedioate = 13.5 × 1.08 = 14.6g (1) number of moles = $\frac{14.6}{146}$ = 0.100 mol (1)		2		2		
		(ii)		$\frac{88.04 \times 0.100 \times 57}{100}$ = 5.02 g			1	1	1	
		(iii)		award (1) for each of following used more than 13.5 cm^3 of diethyl ethanedioate the product was damp / wet / not dry			2	2		2
	(d)	(i)		330	1			1		
		(ii)		$CH_3 \rightarrow 15$ $COOCH_2CH_3 \rightarrow 73$ (1) therefore $C_xH_y \rightarrow 330 – (15 + 73) = 242$ (1)		1	1	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		moles of hydrogen = $\frac{7.35}{24.5}$ = 0.300 mol (1) mole ratio = $\frac{0.300}{0.060}$ = 5 there are 5 –CH=CH– groups in each molecule of E-EPA (1)			2	2		
		(iv)		C_xH_y → 242 5 –CH=CH– groups → 5 × 26 = 130 mass remaining → 242 – 130 = 112 (1) each CH_2 group → 14 therefore number of CH_2 groups → $\frac{112}{14}$ = 8 (1)			2	2		
				Question 9 total	**6**	**6**	**8**	**20**	**1**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)	I	 award (1) each for up to **three** of following curly arrows and addition of $^{-}$CN capture of H^{+} partial and full charges dissociation of HCN into H^{+} and $^{-}$CN		3		3		
			II	nucleophilic addition	1			1		
		(ii)		sulfuric acid / hydrochloric acid	1			1		
		(iii)		it is a racemic mixture / an equimolar mixture of the two enantiomers			1	1		
		(iv)		it does not contain a chiral centre / no asymmetric carbon atom		1		1		
		(v)	I	it acts as a carboxylic acid 		1	1	2		
			II	it acts as an alcohol (giving an ester)		1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)		orange to green (accept colourless to green)	1			1		1
		(ii)		**Indicative content** • distillate placed in a separating funnel • add water to the distillate • add ethoxyethane to the funnel • equal volume of ethoxyethane as distillate • (stopper) and shake • allow to separate • run off lower aqueous layer • treat ethoxyethane layer with anhydrous magnesium sulfate • remove magnesium sulfate (by filtration/decanting) • remove ethoxyethane by distillation • use of heating mantle		3	3	6		6

5-6 marks
All the essential steps described in logical order to ensure a dry sample of pentan-2-one
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 correct steps described (although order may not be correct); safe method involving no naked flames
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 correct steps in separation method
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
		(iii)		no peak seen at 3200-3500 cm^{-1} (due to the OH group in the alcohol) accept no peak seen at 1000-1300 cm^{-1} (due to the C—O group in the alcohol)		1		1		
		(iv)		alkaline iodine / KI and NaOCl (1) yellow precipitate / solid forms (1) do **not** accept 2,4-DNPH test		2		2		2
				Question 10 total	**3**	**12**	**5**	**20**	**0**	**9**

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	9	4	2	15	0	3
5	5	8	3	16	1	1
6	6	8	2	16	3	4
7	5	6	4	15	1	5
8	4	9	5	18	3	4
9	6	6	8	20	1	3
10	3	12	5	20	0	9
Totals	38	53	29	120	9	29