GCE A LEVEL MARKING SCHEME

SUMMER 2019

A LEVEL
CHEMISTRY - COMPONENT 2
A410U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2019 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

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.

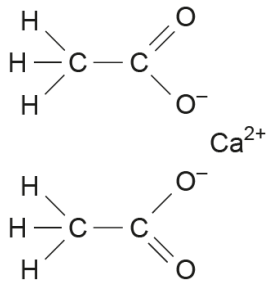
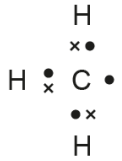
Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			nucleophilic addition	1			1		
	(b)			dilute hydrochloric acid / dilute sulfuric acid	1			1		
	(c)			C_2H_4O	1			1		
	(d)			award (1) for any of following • lithium tetrahydridioaluminate(III) • lithium aluminium hydride • $LiAlH_4$ do not accept $NaBH_4$	1			1		
2	*(a)*			award (1) for any of following • sodium nitrite and hydrochloric acid • sodium nitrate(III) and hydrochloric acid • $NaNO_2$ and HCl • nitric(III) acid / HNO_2 temperature 10°C (or below) (1)	2			2		2
	(b)			award (1) for either of following • it absorbs all the other colours of the visible spectrum and reflects yellow • it absorbs the blue end of the visible spectrum and reflects yellow		1		1		

<table>
<tr><th colspan="4">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>3</td><td></td><td></td><td></td><td>benzamide would react with the sodium hydroxide giving sodium benzoate and ammonia</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
<tr><td>4</td><td></td><td></td><td></td><td>award (1) each for any two correct rows

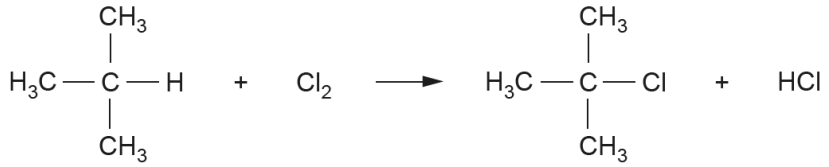
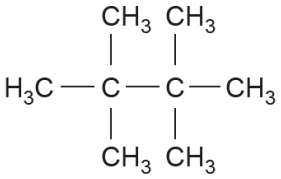
<table>
<tr><th>Reagent(s) used</th><th>Result with benzoic acid</th><th>Result with 2-hydroxybenzaldehyde</th></tr>
<tr><td>Na_2CO_3 / $NaHCO_3$</td><td>effervescence</td><td>no reaction</td></tr>
<tr><td>Tollens’ reagent</td><td>no reaction</td><td>silver mirror</td></tr>
<tr><td>$FeCl_3$(aq)</td><td>no reaction / brownish precipitate or colouration</td><td>purple coloration</td></tr>
<tr><td>acidified dichromate (heat)</td><td>no reaction</td><td>orange to green</td></tr>
<tr><td>2,4-DNPH</td><td>no reaction</td><td>orange / red precipitate</td></tr>
<tr><td>Br_2(aq)</td><td>no reaction</td><td>decolourised</td></tr>
</table>

accept Fehling's solution (giving red/brown solid with aldehyde) as alternative to Tollens' mark</td><td>1</td><td>1</td><td></td><td>2</td><td></td><td>2</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5						1		1		
6				 do not accept diagram with a charge shown	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*			M_r urea = 60 **and** M_r melamine = 126 (1) **both** needed atom economy = $\frac{126 \times 100}{6 \times 60}$ = 35 (1)	1	1		2		
	(b)			percentage = $\frac{84 \times 100}{126}$ = 66.7 / 67 ecf possible from incorrect M_r in *(a)*	1			1		
				Section A total	**10**	**4**	**1**	**15**	**0**	**5**

Section B

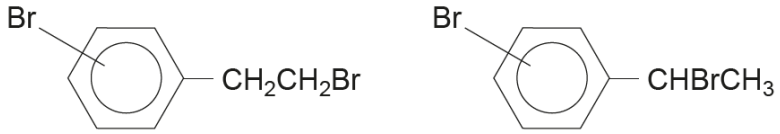
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	(i)			1			1		
		(ii)		attack by a chlorine radical/atom on a chlorinated alkane product		1		1		
		(iii)		award (1) for any of following • $(CH_3)_3C\bullet$ radical is the more stable • E_a for the reaction is lower • formation of 2-chloro-2-methylpropane is faster			1	1		
		(iv)		 (1) all the protons are equivalent (1)		1	1	2		
		(v)		award (1) for either of following $(CH_3)_3CH + \frac{13}{2} O_2 \rightarrow 4CO_2 + 5 H_2O$ $C_4H_{10} + \frac{13}{2} O_2 \rightarrow 4CO_2 + 5 H_2O$		1		1		

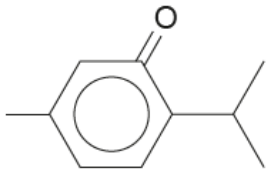
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			$CH_2ClF \rightarrow \bullet Cl + \bullet CH_2F$ (1) if equation is correct award (1) for any of following • C—Cl is the weakest of the bonds • C—Cl bond is weaker than C—H, C—Cl and C—F bonds • only C—Cl bond is weak enough for homolytic fission by UV		2		2		
	(c)			168 dm^3 is the volume of 7.5 mol (1) 7.5 mol methane has mass 120 g (1) 900 g of methane clathrate ⇨ 120 g of methane and 780 g water number of moles of water = $\frac{780}{18}$ = 43.3 (1) ratio 43.3 : 7.5 ⇨ 5.8 : 1 (1)		2	2	4	2	

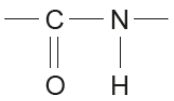
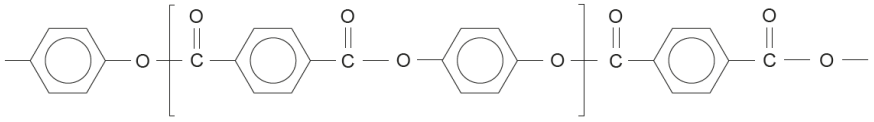
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		award (1) for any of following • needs high temperature • needs lots of energy • toxic products	1			1		
		(ii)	I	a reaction that involves <u>decomposition</u> by <u>water</u>	1			1		
			II	filter, wash (with water) and dry		1		1		1
			III	award (1) for either of following • melts at a lower temperature • melts over a range of temperatures	1			1		1
			IV	decarboxylation do not accept elimination		1		1		
			V	overall percentage yield = $\frac{90}{100} \times \frac{50}{100}$ = 45 % (1) number of moles of CS gas = $\frac{75000}{189}$ = 396.8 mol (1) 45 % yield therefore 396.8 × 0.45 = 178.56 mol (1) mass of (2-phenyl)ethene = 178.56 × 139 = 24.8 kg (1) final answer **must** be given to 3 sig figs	1	3		4	1	
				Question 8 total	**5**	**12**	**4**	**21**	**3**	**2**

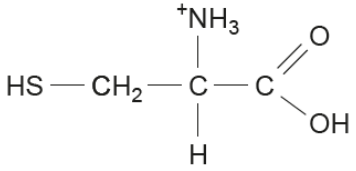
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*			**Indicative content** • O—H bond at 3200-3500 cm^{-1} ⇨ **A** • C—Br bond at 500-600 cm^{-1} and C=C bond at 1620-1670 cm^{-1} ⇨ **D** • C—Br bond at 500-600 cm^{-1} but no C=C bond at 1620-1670 cm^{-1} ⇨ **C** • C=C bond at 1620-1670 cm^{-1} but no C—Br bond at 500-600 cm^{-1} ⇨ **F** • can't distinguish between compounds **B** and **E** credit any sensible alternative approaches to identify **A**, **C**, **D** and **F** • **B** and **E** both have aromatic protons at 6.5-8.0 δ • **B** will have two singlets in the peak area ratio of 3 (methyl) to 2 (methylene) (or 6 to 4) • **E** will have two singlets in the peak area ratio of 3 (methyl) to 1 (methylene) (or 6 to 2)	2	2	2	6		

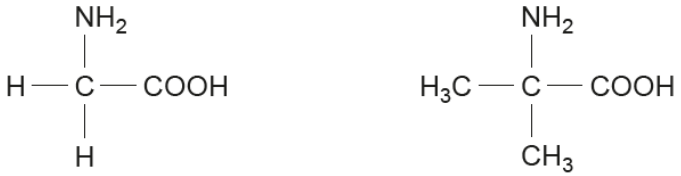
Question				Marking details
				5-6 marks Characteristic IR peaks of compounds **A**, **C**, **D** and **F** clearly identified (bonds and absorption values); difference in ^{1}H NMR spectra of compounds **B** and **E** clearly identified *The candidate constructs a relevant, coherent and logically structured 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** Characteristic IR peaks of compounds **A**, **C**, **D** and **F** identified (bonds or absorption values); attempt made to describe the ^{1}H NMR spectra of compounds **B** and **E** *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 characteristic IR peaks of any compounds identified *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
	(b)			number of moles of **L** = $\frac{3.22}{264}$ = 1.22×10^{-2} mol (1) number of moles of AgBr = 1.22×10^{-2} mol therefore only one bromine atom removed (1) this must be bonded to an aliphatic carbon atom, the other bromine atom must be bonded to the benzene ring (1) award (1) for any suitable structure e.g. 		1 1 1	1	4		
	(c)	(i)	I	total peak area = 94 percentage menthol = $\frac{41 \times 100}{94}$ = 43.62 / 43.6 / 44		1		1		
			II	if an alkane it must be C_9H_{20} (M_r 128) or $C_{10}H_{22}$ (M_r 142) does not fit 136, fewer hydrogen atoms therefore must be unsaturated (1) could be $C_{10}H_{16}$ (1)			2	2		

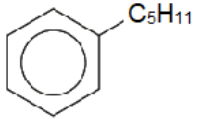
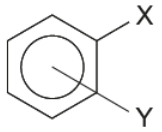
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)	I	3-methylphenol	1			1		
			II	2-chloropropane aluminium chloride / iron(III) chloride reagent and catalyst **both** needed	1			1		1
			III	reduction / hydrogenation			1	1		
		(iii)					1	1		
				Question 9 total	**4**	**6**	**7**	**17**	**0**	**1**

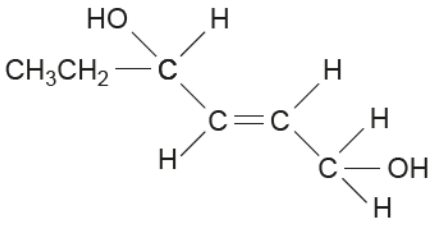
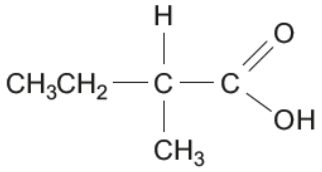
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*	(i)		electrophilic substitution	1			1		
		(ii)		award (1) for either of following • substitution occurs in other positions (giving other isomers) • polysubstitution			1	1		
		(iii)		alkaline potassium manganate(VII)		1		1		
		(iv)	I	$2SO_2 + 2HCl$		1		1		
			II	the other products are gaseous		1		1		1
			III	award (1) for either of following • the acid may react with the ethanol (rather than with $SOCl_2$) • $SOCl_2$ may react with the ethanol (rather than with the acid)			1	1		
		(v)		it contains the  linkage	1			1		
		(vi)		award (1) for either of following • $NaNO_2$ and HCl • HNO_2 / HONO		1		1		
		(vii)					1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(viii)	I	there will be two signals (1) these are in the peak area ratio 12 (aliphatic):4 (aromatic) [or 3 (aliphatic):1 (aromatic)] (1)		2		2		
			II	there will be four signals (1) award (1) for identifying **all** four CH_3 C=O aromatic C—C aromatic C to aliphatic C		2		2		
	(b)	(i)				1		1		
		(ii)	I	relative mass of ethanoic anhydride = 102.09 (1) volume needed = $\frac{102.09 \times 0.250}{1.08}$ = 23.6 cm^3 (1)	1	1		2	1	
			II	$\frac{0.250 \times 90 \times 163}{100}$ = 36.7		1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		e.g.  alkyl / aryl groups **must** be the same		1		1		
				Question 10 total	**3**	**12**	**3**	**18**	**1**	**1**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*	(i)		award (1) for either of following $C_6H_{14} \rightarrow C_6H_6 + 4H_2$ $C_6H_{14} \rightarrow$  $+ 4H_2$		1		1		
		(ii)	I	remove stopper, (open tap), run off lower layer, (close tap)	1			1		1
			II	(simple) distillation (1) water bath / electric heating mantle (1)	2			2		2

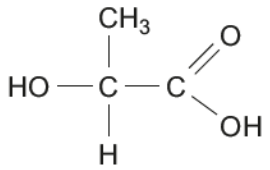
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)		n = $\frac{pV}{RT}$ (1) n = $\frac{1.01 \times 10^5 \times 4.31}{1000 \times 8.31 \times 312}$ = 0.168 mol (1) 3 × C=C bonds present therefore $\frac{0.168}{3}$ = 0.056 mol of ectocarpene (1) M_r = $\frac{8.29}{0.056}$ = 148 (1)		4		4	2	
		(ii)		molecular formula $C_{11}H_{16}$ (1) award (1) for  or any aromatic compound where side chains **X** and **Y** total C_5H_{11} 			2	2		

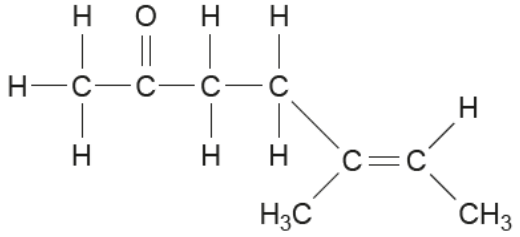
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)					1	1		
		(ii)		silver mirror (1) an aldehyde group is present **and** this reduces Ag^+ ions to Ag (1)	1	1		2		1
	(d)			 (1) $(CH_3)_3C—COOH$ (1)	1		1	2		
				Question 11 total	**5**	**6**	**4**	**15**	**2**	**4**

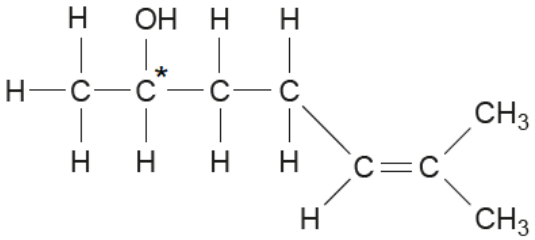
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	*(a)*			**Indicative content** • compounds **A** and **B** - van der Waals forces only, no hydrogen bonding (between molecules) • compounds **C**, **D** and **E** have hydrogen bonding - stronger than van der Waals forces in **A** and **B** • boiling temperatures of **A** and **B** are lower than **C**, **D** and **E** • boiling temperature of **A** is lower that of **B** because of weaker intermolecular / van der Waals force due to 'weaker' packing • the more branched the chain, the lower the boiling temperature because packing / van der Waals forces are weaker • the straight chain isomer **E** has the highest boiling temperature because of stronger intermolecular forces due to more efficient packing	2	2	2	6		

Question				Marking details
				5-6 marks Clear distinction made between van der Waals forces in the ethers and hydrogen bonding in the alcohols; valid suggestion made for the differences in boiling temperatures between **A** and **B** and between **C**, **D** and **E** *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** Some distinction made between van der Waals forces in the ethers and hydrogen bonding in the alcohols, reasonable attempt made at explaining the difference in the boiling temperatures between **A** and **B** or between **C**, **D** and **E** *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 attempt made to account for the differences in boiling temperatures between the ethers and the alcohols *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
	(b)	(i)		award (1) for either of following • it reacts and is <u>regenerated</u> • it increases the rate of the reaction <u>but is not used up</u>		1		1		
		(ii)		it is a lone pair donor / proton acceptor	1			1		
		(iii)		elimination of water can occur as a result of the loss of 'OH' and a proton from the carbon atoms on either side of the carbon atom with the —OH group bonded to it			1	1		
		(iv)		1 mol / 24500 cm^3 of hydrogen from 2 mol of the alcohol mass of 2 mol of the alcohol = 176.2 g (1) mass in the mixture = $\frac{125 \times 176.2}{24500}$ = 0.899 / 0.90 g (1)		2		2	1	
		(v)	I	peak **B** because this is the major product of the reaction		1		1		
			II	award (1) for any of following • measure the retention time with a known sample • add some 2-methylbutan-2-ol to the reaction product and see which peak becomes relatively larger • look up the retention time value			1	1		1
		(vi)		by the elimination of one molecule of water from two molecules of the alcohol accept alternative answers based on correct mechanistic suggestions			1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)			1			1		
		(ii)		award (1) each for any **two** of following • does not react with hot water / drink / liquids • stable chemically to at least 50°C • melting temperature / softening point is greater than 50°C • non-toxic / does not affect skin		2		2		
				Question 12 total	**4**	**8**	**5**	**17**	**1**	**1**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	*(a)*			number of moles of NaOH used = $\frac{50.0 \times 0.500}{1000}$ = 0.0250 mol (1) number of moles that reacted the diacetin = 0.0180 mol (1) 2 mol of NaOH react with 1 mol of diacetin therefore number of moles of diacetin is 0.0090 mol (1) M_r of diacetin = $\frac{1.58}{0.0090}$ = 175.5 / 176 (1)	2	2		4		
	(b)	(i)		both of the groups attached to one of the carbon atoms in the C=C double bond are the same	1			1		
		(ii)		e.g.  credit any suitable structure			1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		award (1) for appropriate reagents • KI / NaOCl • alkaline I_2 yellow precipitate (1)	2			2		2
		(iv)		award (1) for correct structure  award (1) for correct chiral centre		1	1	2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{377 \times 10^{-9}} = 7.96 \times 10^{14}$ Hz (1) $E = hf = 6.63 \times 10^{-34} \times 7.96 \times 10^{14} = 5.28 \times 10^{-19}$ J (1) energy per mol = $6.02 \times 10^{23} \times 5.28 \times 10^{-19}$ 317.7 / 318 kJ mol^{-1} (1)		3		3	3	
		(ii)	I	bromine is decolourised (1) white precipitate (1)			2	2		2
			II	electrophilic addition		1		1		
			III	4 : 1			1	1		
				Question 13 total	**5**	**7**	**5**	**17**	**3**	**4**

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	10	4	1	15	0	5
8	5	12	4	21	3	2
9	4	6	7	17	0	1
10	3	12	3	18	1	1
11	5	6	4	15	2	4
12	4	8	5	17	1	1
13	5	7	5	17	3	4
Totals	36	55	29	120	10	18