GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
CHEMISTRY – COMPONENT 2
A410U20-1

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INTRODUCTION

This marking scheme was used by WJEC for the 2023 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.

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GCE A LEVEL CHEMISTRY

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMER 2023 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.

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Marking abbreviations

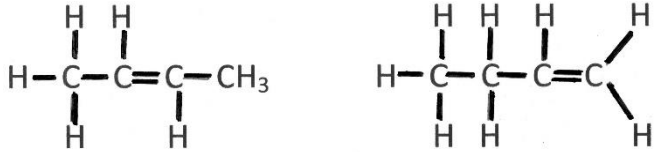
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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

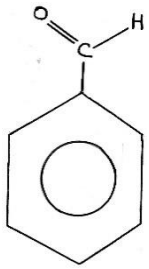
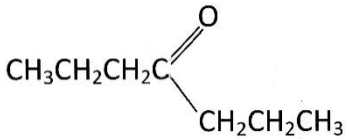
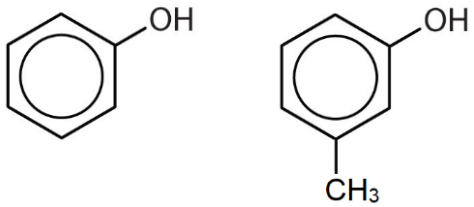
Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

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Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1				bond fission where each atom in the bond receives an electron from the bond (1)  (1) accept $CH_3CH_3 \rightarrow CH_3CH_2\bullet + H\bullet$	2			2		
2				award (1) each for following isomers 		2		2		
3				award (1) for correct formulae of both products $CH_3CH_2CH_2COOCH_2CH_3 + H_2O$ ethyl butanoate (1)		2		2		

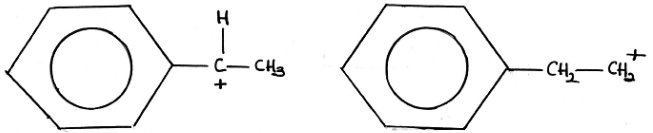
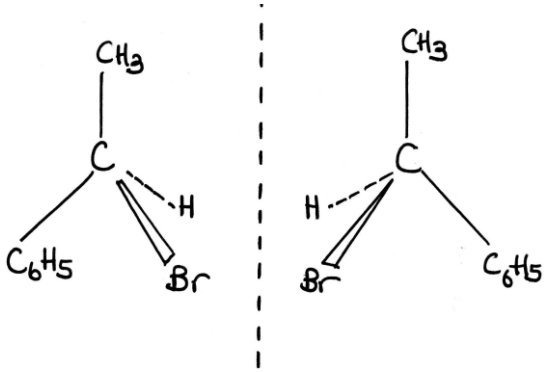
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4				reagent **X** lithium tetrahydridoaluminate / $LiAlH_4$ (1) reagent **Y** nitric(III) acid / HNO_2 / $NaNO_2$ and HCl (1)	2			2		2
5	(a)			potassium manganate(VII) (alkaline) / $KMnO_4$	1			1		1
	(b)					1		1		
6							1	1		
7				no colour seen / black			1	1		
8				award (1) for structure of any phenol e.g. 		1		1		1

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			Cl_2 and $AlCl_3$ / $FeCl_3$		1		1		
	(b)			20%	1			1		
				Section A Total	**6**	**7**	**2**	**15**	**0**	**4**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		mechanism proceeds via carbocation intermediates (1)  secondary carbocation is more stable / formed more quickly hence (1-bromoethyl)benzene is the major product (1)		1	1	2		
		(ii)		0.082 × $\frac{85}{100}$ = 0.070 mol (1) mass = 0.07 × 185 = 12.9 g (1)		2		2		
		(iii)		fractional distillation		1		1		1
		(iv)				1		1		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(v)		it does not contain a chiral centre / asymmetric carbon atom		1		1		
	(b)	(i)		nucleophilic substitution		1		1		
		(ii)		nitrogen acts as a base / has a lone pair which reacts with H^+			1	1		
		(iii)	I	KCN / potassium cyanide	1			1		1
			II	the value/intensity of the absorption at 2100-2250 cm^{-1} decreases because the C≡N bond is replaced (by a C—N bond) during the reaction	1			1		
			III	reduction / addition	1			1		
	(c)			award (1) each for any **three** of following temperature pressure whether any impurities are present that also produce nitrogen excess of nitric(II) acid needed physical state of the amine whether there are any other gaseous products			3	3		3
	(d)			mass of nitrogen / 14 is 7.91% of M_r $M_r = \frac{14}{7.91} \times 100 = 177$ (1) 'M_r' of $C_6H_5CH_2CH_2NHCO$ fragment = 148 (1) 'M_r' of R = 29 ⇨ R is CH_3CH_2 / C_2H_5 (1)	1	1	1	3	1	
				Total question 10	**4**	**8**	**6**	**18**	**1**	**5**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			**Indicative content** • with sodium hydrogencarbonate methyl methanoate ⇨ no obvious reaction ethanoic acid ⇨ effervescence / CO_2 evolved ⇨ shows that it is acidic • with universal indicator methyl methanoate ⇨ turns green ⇨ pH7 / neutral / no H^+ or OH^- ions present ethanoic acid ⇨ turns orange ⇨ pH<7 / weakly acidic / H^+ ions present • boiling temperature methyl methanoate – dipole-dipole interactions, lower boiling temperature ethanoic acid – hydrogen bonding, higher boiling temperature • ^1H NMR methyl methanoate single hydrogen at 9.8 (accept values in range 8-10) methyl hydrogens at 3.3-4.3 peak area ratio 3:1 with no splitting ethanoic acid single hydrogen at 11.0 (accept values ~11) methyl hydrogens at 2.0-2.5 with no splitting	2	2	2	6		4

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks All essential points described in a reasoned and logical manner *The candidate constructs an articulate, integrated account, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses scientific conventions and vocabulary appropriately and accurately*. **3-4 marks** Basic details of most points described *The candidate constructs an account correctly linking some relevant points showing some reasoning. The answer addresses the question with some omissions. The candidate usually uses scientific conventions and vocabulary appropriately and accurately*. **1-2 marks** Attempt at basic description of some points *The candidate makes some relevant points showing limited reasoning. The answer addresses the question with significant omissions. The candidate makes limited use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give a relevant answer worthy of credit.*						
	(b)	(i)		award (1) for temperature in the range 140-160°C as the chain length increases by each CH_2 the boiling temperature increased by about 30°C (as van der Waals forces increase) (1)	1	1		2		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		intermolecular forces / dipole-dipole interactions are weaker / 'packing' is less strong (due to less surface area contact) (1) less energy is required to separate the molecules into the gas phase (1)		2		2		
	(c)			100 m^3 = 100 × 10^3 dm^3 = 10^5 dm^3 in 10^6 dm^3 there needs to be 5 dm^3 of tetrahydrothiophene in 10^5 dm^3 there needs to be 0.50 dm^3 of tetrahydrothiophene (1) 1 mol of tetrahydrothiophene at 298 K and 1 atm occupies 24.5 dm^3 0.50 dm^3 = $\frac{0.50}{24.5}$ = 0.0204 mol (1) mass of liquid = 88 × 0.0204 = 1.8 g as density of liquid is 1.0 g cm^{-3} this is 1.8 cm^3 of the liquid (1)			3	3	2	
	(d)			$C_4H_8S + 7O_2 \rightarrow 4CO_2 + 4H_2O + SO_2$		1		1		
	(e)			moles of 2,4,6-tribromophenol = $\frac{4.58}{331}$ = 0.0138 mol mass of phenol = 0.0138 × 94 = 1.30 g (1) concentration = $\frac{1.30}{\frac{150}{1000}}$ = 8.67 g dm^{-3} (1)		2		2	1	
				Total question 11	**3**	**8**	**5**	**16**	**3**	**4**

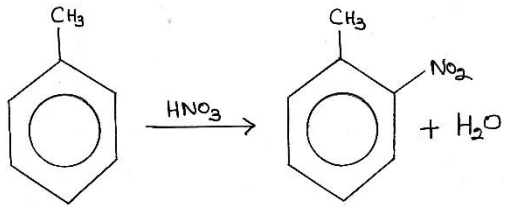
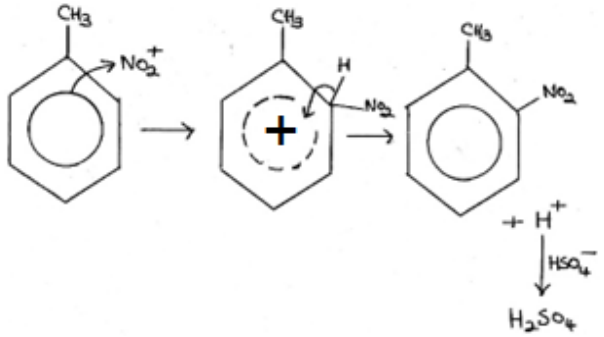
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)	(i)		(deep) blue Fehling's solution (1) gives a red / brown precipitate (1)	2			2		2
		(ii)		award (1) for name/formula of any aliphatic aldehyde e.g. propanal / CH_3CH_2CHO do not accept benzaldehyde / C_6H_5CHO		1		1		
	(b)	(i)		nucleophilic addition	1			1		
		(ii)		decomposition by water / dilute acid	1			1		
	(c)			award (1) each for any **two** of following loss of (volatile) ethanal incomplete oxidation / further oxidation side reactions			2	2		2
	(d)			moles of NaOH = $0.200 \times \frac{40.0}{1000}$ = 0.0080 mol (1) moles of lactic acid reacted = 0.0080 mol mass of lactic acid reacted = $0.0080 \times 90.06 = 0.72$ g (1) volume of lactic acid = $\frac{0.72}{1.2}$ = 0.60 cm^3 percentage = $\frac{0.60}{75} \times 100 = 0.8\%$ (1)		2	1	3	1	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)		CH_3 (at 1.66 ppm) is a doublet since the adjacent carbon atom has one hydrogen atom bonded to it (1) H (at 5.09 ppm) is a quartet since the adjacent carbon atom has three hydrogen atoms bonded to it (1)		2		2		
		(ii)		absorption at 1266 cm^{-1} caused by C—O bond absorption at 1750 cm^{-1} caused by C=O bond both needed – accept bonds identified on the structure		1		1		
		(iii)		$(CH_3(CH_2)_6COO)_2Sn$			1	1		
				Total question 12	**4**	**6**	**4**	**14**	**1**	**4**

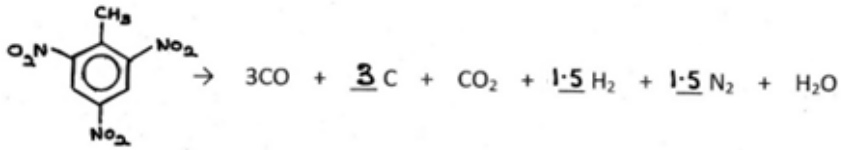
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)			**Indicative content**  • concentrated nitric and sulfuric acids / nitrating mixture • nitrating mixture added to the methylbenzene (to avoid poly-nitration) • $HNO_3 + 2H_2SO_4 \rightarrow 2HSO_4^- + H_3O^+ + NO_2^+$ • NO_2^+ is the electrophile  • mechanism is electrophilic substitution • separation by fractional distillation • other mono-nitrated isomers can be formed	3	3		6		3

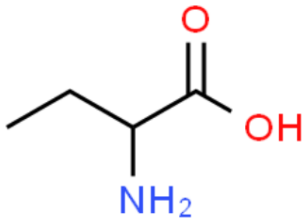
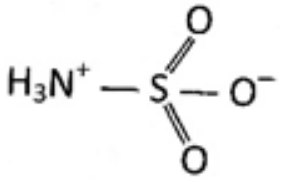
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Good account of most points including the reagents, equation and mechanism *The candidate constructs an articulate, integrated account, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses scientific conventions and vocabulary appropriately and accurately*. **3-4 marks** Basic description of most points; attempt at mechanism *The candidate constructs an account correctly linking some relevant points showing some reasoning. The answer addresses the question with some omissions. The candidate usually uses scientific conventions and vocabulary appropriately and accurately*. **1-2 marks** Some knowledge of the reaction *The candidate makes some relevant points showing limited reasoning. The answer addresses the question with significant omissions. The candidate makes limited use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give a relevant answer worthy of credit.*						

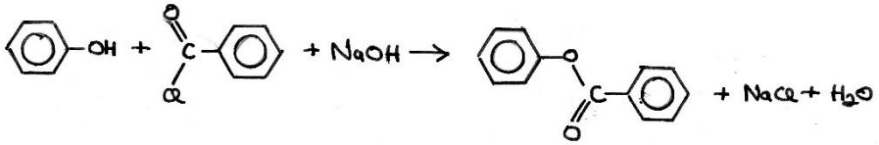
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			dissolve sample in the minimum volume of hot ethanol (1) filter solution hot (1) allow filtrate to cool (1) filter, (wash) and dry crystals (1)	3	1		4		4
	(c)			Sn / Fe and concentrated hydrochloric acid		1		1		1
	(d)	(i)		nitric(II) acid / HNO_2 / HONO / $NaNO_2$, HCl	1			1		1
		(ii)		5-10^oC accept below 10^oC		1		1		1
	(e)						1	1		
				Total question 13	**7**	**6**	**1**	**14**	**0**	**10**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	(a)	(i)	I	2-aminobutanoic acid		1		1		
			II			1		1		
		(ii)		award (1) for either of following $CH_3CH_2CH_2CH(NH_2)COOH$ $(CH_3)_2CHCH(NH_2)COOH$		1		1		
	(b)	(i)		more energy needed to overcome strong ionic forces between 'molecules'	1			1		
		(ii)					1	1		
	(c)	(i)		award (1) for any of following phosphorus(III) chloride / PCl_3 phosphorus(V) chloride / PCl_5 sulfur dichloride oxide / thionyl chloride / $SOCl_2$	1			1		

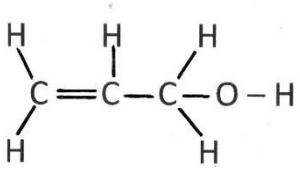
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		award (1) for either of following inorganic covalent halides react with water benzoyl chloride reacts with water		1		1		
		(iii)	I	 award (1) for reactants award (1) for products			2	2		
			II	melting temperature would be below 69°C and not at a single sharp value accept – it would melt below 69°C and over a range of temperatures	1			1		1
	(d)	(i)		105 ⇨ $C_6H_5CO^+$ 121 ⇨ $C_6H_4CO(OH)^+$			1	1		
		(ii)		OH group ⇨ in the range 3200-3550 cm^{-1}	1			1		
		(iii)		award (1) for any of following sodium tetrahydridoborate(III) / $NaBH_4$ lithium tetrahydridoaluminate(III) / $LiAlH_4$		1		1		1

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)		0.020 mol compound **A** produces 0.020 mol H_2 gas volume = 0.020 × 24.5 = 0.49 dm^3 at 298 K (1) $\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow V_2 = \frac{V_1 T_2}{T_1}$ volume at 373 K = $\frac{0.49 \times 373}{298}$ = 0.613 dm^3 (1) accept alternative method using $pV = nRT$ $V = \frac{nRT}{p} = \frac{0.020 \times 8.31 \times 373}{1.01 \times 10^5}$ = 6.14×10^{-4} m^3 (1) V = 0.614 dm^3 (1)		2		2	2	
				Total question 14	**4**	**7**	**4**	**15**	**2**	**2**

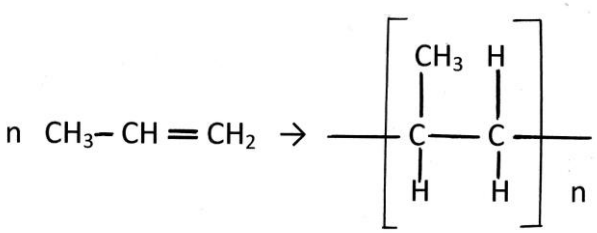
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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15	(a)	(i)		mass of carbon = $0.4414 \times \frac{27.27}{100} = 0.1204\,g$ (1) mass of hydrogen = $0.1809 \times \frac{11.21}{100} = 0.0203\,g$ (1) mass of oxygen = 0.1940 – (0.1204 + 0.0203) = 0.533 g (1) carbon ⇨ $\frac{0.1204}{12} = 0.01$ hydrogen ⇨ $\frac{0.0203}{1.01} = 0.02$ oxygen ⇨ $\frac{0.0533}{16} = 0.0033$ carbon : hydrogen : oxygen ratio ⇨ 3 : 6 : 1 therefore empirical formula is C_3H_6O (1) molecular formula is C_3H_6O because the alcohol only contains one oxygen atom (1)		2	3	5	2	
		(ii)				1		1		
	(b)	(i)		award (1) for any of following acidified dichromate potassium dichromate and sulfuric acid $Cr_2O_7^{2-}$ / H^+	1			1		1

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		hydrogen is being added	1			1		
		(iii)		two peaks (1) one due to the pair of central carbon atoms at δ 50-90 ppm one due to the four methyl carbon atoms at δ 5-40 ppm (1)		1	1	2		
		(iv)	I	they both contain the CH_3CO group or its precursor $CH_3CH(OH)$	1			1		
			II	award (1) for reagents NaOH / I_2 NaOCl / KI yellow solid / precipitate (1)	2			2		2
		(v)		rearrangement a movement of atoms within the structure (or similar) (1) elimination removal or loss of water / small molecules (1)	1		1	2		
				Total question 15	**6**	**4**	**5**	**15**	**2**	**3**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
16	(a)	(i)		elimination / dehydrohalogenation		1		1		
		(ii)		award (1) for equation for any addition polymerisation e.g. 		1		1		
		(iii)		a small molecule is eliminated during condensation polymerisation (but this does not occur in addition polymerisation)	1			1		
	(b)			they cause rotation (to the left or to the right)	1			1		
	(c)	(i)		bromine atoms bonded to an aromatic ring are not susceptible to attack by nucleophiles		1		1		
		(ii)		cream / off-white precipitate		1		1		1

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		mass of compound **S** = 5.50 × 1.73 = 9.52 g (1) moles of compound **S** (if pure) = $\frac{9.52}{264}$ = 0.0360 mol (1) mole ratio compound S : AgBr ⇨ 1:1 therefore 0.0360 mol of AgBr mass of AgBr (if compound **S** is pure) = 0.0360 × 188 = 6.77 g (1) percentage purity = $\frac{5.69}{6.77}$ × 100 = 84.0% (1)		1 1 1	1 1	4	2	
		(iv)		compound **S** will give two signals in a 1:1 peak area ratio (1) compound **T** will give two signals in a 3:1 peak area ratio (1)		2		2		
		(v)		compound **U** has hydrogen atoms bonded to a carbon atom that has no hydrogen atoms on the adjacent carbon			1	1		
				Total question 16	**2**	**8**	**3**	**13**	**2**	**1**

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COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL	Maths	Practical
Section A	6	7	2	**15**	0	4
10	4	8	6	**18**	1	5
11	3	8	5	**16**	3	4
12	4	6	4	**14**	1	4
13	7	6	1	**14**	0	10
14	4	7	4	**15**	2	2
15	6	4	5	**15**	2	3
16	2	8	3	**13**	2	1
Totals	**36**	**54**	**30**	**120**	**11**	**33**

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