A2 UNIT 4: 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 questions where a banded 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.

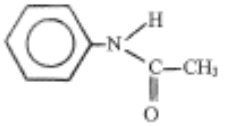
cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

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

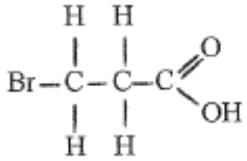
A2 UNIT 4: ORGANIC CHEMISTRY AND ANALYSIS

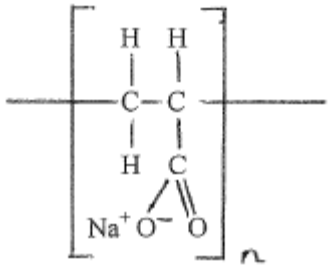
MARK SCHEME

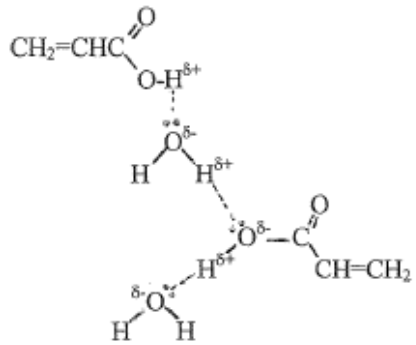
Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1.				$C_6H_5NH_2$ or other primary aromatic amine	1			1		
2.					1			1		
3.				melts over a range of lower temperatures	1			1		
4.				total peak area excluding compound **D** is 96 – equivalent to 80 % peak area compound **D** (20%) is 96 / 4 = 24		1		1		
5.				phenylmethylamine / benzylamine		1		1		
6.	*(a)*			nucleophilic addition	1			1		
	(b)			butanal		1		1		
7.				C_6H_6		1		1		
8.				*least soluble* **B A D C** *most soluble*		1		1		
9.				2-methylpropan-1-ol		1		1		
				Section A total	**4**	**6**	**0**	**10**	**0**	**0**

Section B

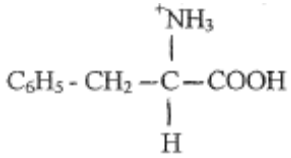
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	*(a)*			C_9H_{20}		1		1		
	(b)			use of a catalyst will not affect the enthalpy change of reaction (1) Hess's law states that the overall enthalpy change is independent of the pathway taken (1)	2			2		
	(c)			 (1) this compound does not contain a chiral centre / an asymmetric carbon atom (which would give rise to enantiomers) (1)			1 1	2		
	(d)			propenoic acid contains a C=C bond at 1620-1670 cm^{-1} (not present in 3-oxetanone) (1) propenoic acid contains an O–H bond at 2500-3550 cm^{-1} (not present in 3-oxetanone) (1)		2		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	*(e)*			M_r sodium propenoate 94.0 (1) moles of propenoic acid = $\frac{38.3 \times 1000}{72.0}$ = 532 ∴ moles of sodium propenoate = 532 ∴ mass of sodium propenoate = 532 × 94.0 = 50.0 (kg) (1) alternatively M_r sodium propenoate 94.0 (1) mass of sodium propenoate = $\frac{38.3 \times 94.0}{72.0}$ = 50.0 (kg) (1)		2		2	1	
	(f)					1		1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10.	*(g)*			for example  correct atoms involved in hydrogen bonding (1) lone pairs and dipoles correctly shown (1)		2		2		
	(h)			any three valid considerations for (1) each up to max 3 for example • cost of propane v cost of propene • yield of propenenitrile in each method • effectiveness of catalyst(s)			3	3		
				Question 10 total	**2**	**8**	**5**	**15**	**1**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11.	*(a)*	(i)		butane-1,4-diol / butan-1,4-dial (1) acidified potassium dichromate / H^+,$Cr_2O_7^{2-}$ (1)	1	1		2		1
		(ii)	I	7 mol glucose give 12 mol butane-1,4-dicarboxylic acid (1) 7 × 180 g glucose give 12 × 118 g butane-1,4-dicarboxylic acid ∴ 1 g glucose gives $\frac{12 \times 118}{7 \times 180}$ g butane-1,4-dicarboxylic acid (1) = 1.12 (kg) (1) **or** 7 mol glucose give 12 mol butane-1,4-dicarboxylic acid (1) 1 mol glucose gives 12/7 mol butane-1,4-dicarboxylic acid = 1.71 mol moles glucose used = 1000/180 = 5.56 moles butane-1,4-dicarboxylic acid obtained = 1.71 × 5.56 = 9.51 (1) ∴ mass of butane-1,4-dicarboxylic acid = $\frac{9.51 \times 118}{1000}$ = 1.12 kg (1)		3		3	3	
			II	carbon dioxide is used and this helps to reduce the greenhouse effect			1	1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11.	*(b)*	(i)		mass H_2SO_4 = 294 g (1) volume H_2SO_4 = 160 cm^3 (1) ecf possible award (2) for cao		2		2	2	
		(ii)		e.g. reflux for longer (1) use stronger / weaker / more aqueous sulfuric acid (1)			2	2		2
		(iii)		there will be less dipole / dipole forces between molecules of 2-methylfuran than between molecules of furfural (1) therefore less energy (1) will be needed to separate them / overcomes these intermolecular forces, giving a lower boiling temperature for 2-methylfuran (1)		3		3		
		(iv)		absorption strongest around 430 nm in the blue-violet (1) low absorption for yellow / in the green to orange region (1)			2	2		2
				Question 11 total	**1**	**9**	**5**	**15**	**5**	**5**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12.	*(a)*	(i)		C_6H_5–CH(COOH)–NH–C(O)CH(NH_2)C_6H_5		1		1		
		(ii)				1		1		
	(b)			3-phenylpropanoic acid has largely van der Waals forces between molecules (1) hydrogen bonding between the acid groups has only a limited effect as these are a small part of a larger molecule, therefore melting temperature is relatively low (1) in 3-phenyllactic acid the hydrogen bonding has a greater contribution to the overall intermolecular bonding as both –OH and –COOH groups can participate, therefore its melting temperature is relatively higher (1) phenylalanine exists as a zwitterion structure as a solid this structure has a strongly bonded ionic style lattice and therefore its melting temperature is much higher / very high (1)		1 1	 1 1 	 4		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12.	*(c)*	(i)		Tollens' (1) silver mirror with phenylethanal but no change with phenylpyruvic acid (1) accept Fehling's test or sodium hydrogencarbonate test	1	1		2		2
		(ii)		2-phenylethanol M_r 122 122 – 91 → 31 (1) (loss of 31 could be CH_2OH^+), fragment could be $C_6H_5CH_2^+$ (1)			2	2		
		(iii)		reagents used are I_2/NaOH or NaOCl/KI (1) yellow solid forms (1) only 1-phenylethanol has a $CH_3C{=}O$ or $CH_3CH(OH)$ group present (1)	1 1		 1	 3		 2
				Question 12 total	**3**	**5**	**5**	**13**	**0**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13.	*(a)*			benzene-1,4-dicarboxylic acid / terephthalic acid		1		1		
	(b)			bond between the chlorine atom(s) and the ring is strong(er) (1) because of the interaction of chlorine's lone pair of electrons with the π-electron system of the ring (1)	2			2		
	(c)			e.g. $AlCl_3$ / $FeCl_3$ / Fe (1) ---------- + **2**Cl_2 → ---------- + **2HCl** (1)	1	 1		 2		
	(d)	(i)		purple solution	1			1		1
		(ii)		white precipitate / solid (1) 2,6-dibromo-4-chloro-3,5-dimethylphenol (1)	1	 1		 2		 2
		(iii)		PCMX → C_8H_9ClO → M_r 157 / 156.6 (1) 250 cm^3 → 12.0 g ∴ 1000 cm^3 → 48.0 g molar concentration = 48.0 / 157 = 0.307 (mol dm^{-3}) (1) ecf possible award (2) for cao		2		2	2	
		(iv)		three peaks (1) as there are three different environments for the protons (1) peak areas are: CH_3 protons – 6 CH aromatic protons – 2 OH proton – 1 (1)	 1	1 	 1	 3		
				Question 13 total	**6**	**6**	**1**	**13**	**2**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14.	*(a)*	(i)		$CH_3COOH + C_4H_9OH \rightarrow CH_3COOC_4H_9 + H_2O$		1		1		
		(ii)		moles of butan-1-ol 0.20 moles of ethanoic acid 0.15 (1) butan-1-ol is in excess and yield should be based on the CH_3COOH (1) from the equation (mole ratio 1:1) 0.15 moles of the ester should be formed = $0.15 \times 116 = 17.4$ g (1)		1 1	1	3	3	3
		(iii)		CH_3COOH is neutralised by sodium hydrogencarbonate (1) giving bubbles (of carbon dioxide) (1)	2			2		2
		(iv)		IR spectrum (1) $\rightarrow$ OH peak at 2500-3550 cm^{-1} (1) **or** mass spectrum (1) $\rightarrow$ molecular ion at m/z 74 (1)			2	2		2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14.	*(b)*			Indicative content • M_r of cyclohexanone $C_6H_{10}O$ is 98.1 • % oxygen is $\frac{16 \times 100}{98.1} = 16.3$ • this information agrees with the compound suggested • cyclohexanone is a ketone and will be reduced to a secondary alcohol; this does **not** fit the compound given • cyclohexanone does not contain a C=C and will **not** therefore decolourise aqueous bromine • cyclohexanone has three proton environments and therefore will **not** give 6 discrete peaks in the ^{1}H NMR spectrum • cyclohexanone has four carbon environments and will give four separate peaks in its ^{13}C spectrum; this does **not** fit the compound suggested **5-6 marks** Correct conclusions relating to all information *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** Oxygen content calculated; correct conclusions relating to one reaction and one piece of spectral data *The candidate constructs a coherent account including most of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.*	3		3	6	2	1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14.	*(b)*			**1-2 marks** Relative mass of compound calculated; correct conclusion relating to one reaction or one piece of spectral data *The candidate attempts to link at least two 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.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*						
				Question 14 total	**5**	**3**	**6**	**14**	**5**	**8**

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SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
Section A	4	6	0	10	0	0
10.	2	8	5	15	1	0
11.	1	9	5	15	5	5
12.	3	5	5	13	0	4
13.	6	6	1	13	2	3
14.	5	3	6	14	5	8
TOTAL	**21**	**37**	**22**	**80**	**13**	**20**