GCE A LEVEL MARKING SCHEME

SUMMER 2017

A LEVEL (NEW)
CHEMISTRY - COMPONENT 2
A410U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2017 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.

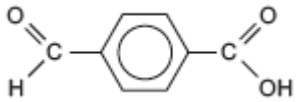
Marking abbreviations

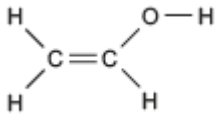
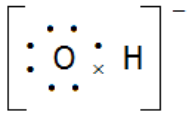
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

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				ultraviolet light is needed to break the Cl—Cl bond / produce chlorine free radicals (1) $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$ (1)	1	 1		 2		
2				C_6H_{14} (1) **4**H_2 (1)	1	 1		 2		
3	(a)			M_r of urea = 60.04 (1) % of nitrogen = $\frac{2 \times 14.0}{60.04} = 46.6$ (1)	1	 1		 2		
	(b)			sodium hydroxide / NaOH / OH^-		1		1		1
4	(a)			potassium manganate(VII) / manganate(VII) / $KMnO_4$ / MnO_4^- do not accept 'acidified'	1			1		1
	(b)			 (1) it must contain an aldehyde group (as these reduce Fehling's solution) (1)		 1	 1	 2		

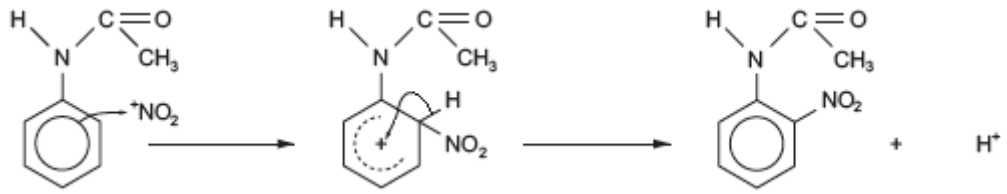
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5						1		1		
6						1		1		
7				add (excess) aqueous sodium carbonate / sodium hydrogencarbonate (to neutralise the acid) (1) separate off the aqueous layer (using a separating funnel) (1) distil the organic layer (collecting the ester at 164 °C) (1)		3		3		3
				Section A total	**4**	**10**	**1**	**15**	**0**	**5**

Section B

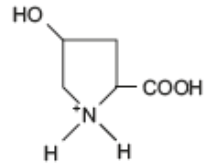
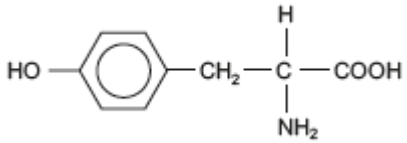
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)	(i)		e.g. hot **and** cold water baths	1			1		1
		(ii)		moles of sucrose used = 25/342 = 0.0731 moles of dihydrate expected = 0.0731 × 6 = 0.439 (1) moles of dihydrate produced = 18.0/126 = 0.143 percentage yield = 0.143 × 100/0.439 = 32.6 accept 33 (1)		2		2	2	
		(iii)		ethanedioic acid – both carbon atoms are in equivalent environments – therefore 1 signal (1) oxopropanoic acid – 2 carbon atoms are in the same environment and the other carbon atom is in a different environment – therefore 2 signals (1)	1	1		2		
	(b)			award (2) for correct equation $CH_3CH=CH_2 + 2HNO_3 + 5/2O_2 \rightarrow (COOH)_2 + CO_2 + 2NO + 3H_2O$ if incorrect award (1) for HNO_3 on the **left hand side only** (1)		2		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			any **two** of following for (1) each • can be used as a renewable feedstock • can be used in countries without petroleum based industries • no CO_2 produced • one step reaction			2	2		
	(d)			100 g $CaCO_3$ from 126 g $(COOH)_2.2H_2O$ 1.00 g $CaCO_3$ from 126/100 g $(COOH)_2.2H_2O$ 0.400 g $CaCO_3$ from 0.400 × 126/100 $(COOH)_2.2H_2O$ = 0.504 g (1) therefore per 100 g of Brussels sprouts 0.504 × 100/140 (1) 0.360 g (1) answer **must** be given to 3 significant figures		3		3	1	
	(e)			61.3 cm^3 from 0.440 g strontium carbonate therefore 24500 cm^3 from 24500 × 0.440/61.3 = 176 (the required M_r)		1		1	1	

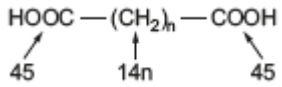
<table>
<tr><th colspan="4">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td>(f)</td><td></td><td></td><td>
<table>
<tr><th>Compound A</th><th>Compound B</th><th>Compound C</th></tr>
<tr><td>no (observable) reaction</td><td>white precipitate / Br_2 decolourised</td><td>white precipitate / Br_2 decolourised</td></tr>
<tr><td>effervescence</td><td>effervescence</td><td>no (observable) reaction</td></tr>
</table>
award (1) per correct column / compound
</td><td>3</td><td></td><td></td><td>3</td><td></td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 8 total</td><td>5</td><td>9</td><td>2</td><td>16</td><td>4</td><td>4</td></tr>
</table>

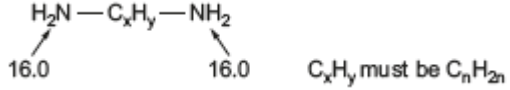
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		ethanoyl chloride / CH_3COCl / ethanoic anhydride / $(CH_3CO)_2O$	1			1		
		(ii)		 correct curly arrows (1) formula of intermediate (1) formulae of products (1)		3		3		
		(iii)		any of following for (1) • run the reaction at a higher temperature / above 50 °C • use an excess of the nitrating agent • add the N-phenylethanamide to the nitrating mixture rather than the reverse addition			1	1		1
		(iv)		dissolve in a <u>minimum</u> volume of the <u>hot</u> solvent (1) filter hot if necessary (1) allow to cool (1) filter, (wash) and dry at <180 °C / room temperature / window sill / warm oven (1)	4			4		4

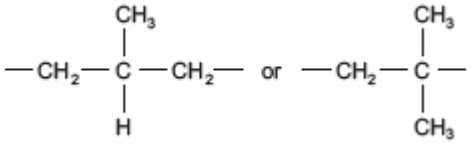
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)		any of following for (1) • nitrous acid • HNO_2 / HONO • sodium nitrite / sodium nitrate(III) + hydrochloric acid • $NaNO_2$ + HCl temperature of 10 °C or less (1)	2			2		2
		(ii)	I	black / no colour as there is no red light to be transmitted / all the light is absorbed			1	1		
			II	red as red light is not absorbed			1	1		
	(c)	(i)		limonene contains two C=C double bonds therefore 2 mol of Br_2 react with 1 mol of limonene (1) therefore 2 × 159.8g / 319.6 g bromine react with 1 mol of limonene moles of bromine used = 9.58/159.8 = 0.060 (1) moles of limonene = 0.030 M_r of limonene = 4.08 / 0.030 = 136 (1)		3		3	2	
		(ii)		there are two C=C bonds present therefore two moles of H_2 are needed for full hydrogenation (1) the M_r therefore increases by 4, hence 140 (1) ecf from part (i)		2		2		
				Question 9 total	**7**	**8**	**3**	**18**	**2**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		the compound (largely) exists as a zwitterion with positive and negative charges (1) these opposite charges are strongly attracted to each other - more energy is needed to overcome these forces therefore higher than expected melting temperature (1)		2		2		
		(ii)					1	1		
	(b)					1		1		
	(c)			groups that take part in this hydrogen bonding are N—H and C=O (1) this occurs because of polarisation in the bonds $N^{\delta-}$—$H^{\delta+}$ and $^{\delta+}C=O^{\delta-}$ (1) (could be shown in a diagram)	2			2		

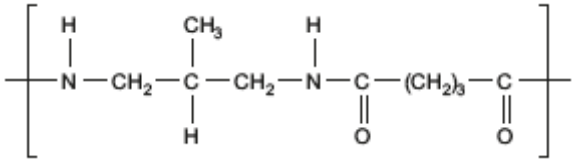
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		alcohols have hydrogen bonding between molecules (could be seen in a diagram) (1) this hydrogen bonding effect is greater when the group is a 'more significant' part of the molecule (1) when the effect of hydrogen bonding is greater (as in methanol) more energy is needed to overcome this attraction, leading to a 'higher' boiling temperature (1)	1	1	1	3		
		(ii)		there is no hydrogen bonding between molecules of the thiols (1) less energy is needed to overcome the relatively weaker van der Waals forces between molecules (compared with the alcohols), leading to relatively lower boiling temperatures (1)		1	1	2		
	(e)	(i)		hydrogen chloride is produced as a gaseous co-product, this is lost from the reaction (1) moves the position of equilibrium to the right (1) the method using ethanoic acid produces water as a co-product and the reaction reaches a position of equilibrium (1)			3	3		
		(ii)		any of following for (1) • hydrogen chloride (gas) is irritant • the reaction needs to be done in a fume cupboard • the reaction needs anhydrous conditions			1	1		1

Question	Marking details	Marks available					
		AO1	AO2	AO3	Total	Maths	Prac
(f)	**Indicative content** • **K** is a dicarboxylic acid – 1 mol of the acid reacts with 2 mol of NaOH • number of moles of NaOH = 0.500 × 37.55 / 1000 = 0.0188 • number of moles of **K** is 0.00939 • M_r of the acid = 1.24/0.00939 = 132 •  132 – 90 = 42 14n = 42 n = 3 • formula of acid **K** is $HOOC(CH_2)_3COOH$		3	3	6	3	

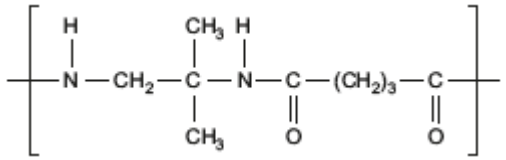
• 2 mol of nitrogen (48000 cm^3) from 1 mol of **L**
• 278 cm^3 from 0.500g **L** ⇒ 49000 cm^3 from 0.500 × 49000/278 = 88.1 M_r **L** is 88
• 

• hence C_4H_8
• C_4H_8 can be arranged —CH_2—CH_2—CH_2—CH_2—
• this has 2 different carbon-containing environments in its ^{13}C NMR spectrum
• alternatively it can be arranged
• 

• these have 3 different carbon-containing environments (as stated in the question) **L** must be $H_2N—CH_2—CH(CH_3)—CH_2—NH_2$ or $H_2N—CH_2—C(CH_3)_2—NH_2$
• the repeating section of the polyamide **J** is



or



				5-6 marks The response shows unambiguous correct formulae for **J**, **K** and **L**. *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** The response shows some unambiguous correct formulae for **J**, **K** and **L**. *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** The response shows a less clear attempt at deriving the formulae of **J**, **K** and **L**. *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 10 total	**3**	**8**	**10**	**21**	**3**	**1**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)	(i)		hydrogenation of one C=C bond is –107 kJ mol^{-1} therefore the hydrogenation of two C=C bonds should be –214 kJ mol^{-1} (1) the energy evolved is actually –153 kJ mol^{-1} therefore resonance / delocalisation energy is 61 kJ mol^{-1} (1)			2	2		
		(ii)		the aldehyde would give an orange-red precipitate (1) whose melting temperature could be compared with the book value for this derivative of but-2-enal (1)	2			2		2
	(b)	(i)		butan-1-ol / $CH_3CH_2CH_2CH_2OH$			1	1		
		(ii)		peak between 1620 and 1670 cm^{-1} would indicate the presence of a C=C double bond if any but-2-enal were present	1			1		
		(iii)		nucleophilic addition	1			1		
		(iv)		oxidation (and reduction) / redox (1) any of following for (1) • acidified (potassium) dichromate • H^+ and $Cr_2O_7^{2-}$ • acidified (potassium) manganate(VII) • H^+ and MnO_4^-	2			2		2
				Question 11 total	**6**	**0**	**3**	**9**	**0**	**4**

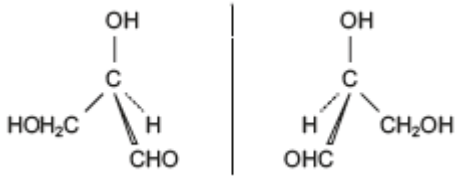
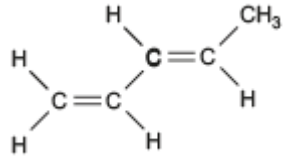
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)	(i)		warm 2-chloroethanol with aqueous sodium hydroxide (1) acidify the mixture with (aqueous) nitric acid (1) add aqueous silver nitrate (1) white precipitate (of silver chloride) confirms the presence of a C—Cl bond (1)	2	2		4		4
		(ii)		chloroethanol to chloroethanoic acid → mole ratio = 1:1 (1) 83% conversion, therefore originally 100 × 0.0600 / 83 = 0.072 mol of chloroethanol (1) mass of 2-chloroethanol = 0.072 × 80.6 = 5.80g (1)		1 1	 1	 3	 1	
	(b)	(i)		it does not contain polar groups (accept examples) that can hydrogen bond with water			1	1		
		(ii)		hydrogen and platinum / nickel catalyst		1		1		
		(iii)		total relative peak area = 48 + 13 + 10 + 9 = 80 (1) 48 is equivalent to 0.018 mol kg^{-1} total concentration = 80 × 0.018 / 48 = 0.030 (mol kg^{-1}) (1)			2	2	1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac

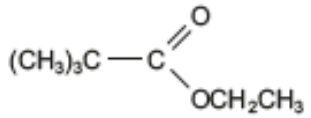
	(c)			**Indicative content**
				• in the upper atmosphere a C—Cl bond is broken by UV radiation
				• giving a chlorine atom / radical
				• $CFCl_3 \rightarrow \bullet CFCl_2 + Cl\bullet$
				• chorine radical attacks ozone
				• $Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$
				• the chlorine radical is regenerated, therefore reaction is catalytic
				• $ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$
				• environmental effects, for example
				  ○ skin cancer
				  ○ plant death
				  ○ global warming
					3	3		6		

				5-6 marks The response includes a good description of reactions leading to breakdown of ozone (could be by chemical equations) and two appropriate environmental effects *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** The response includes a general description of breakdown of ozone and an environmental effect *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** The response is more limited and includes reference to breakdown of ozone / environmental effect *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
	(d)			**Mass spectrum** molecular ions at 154 and 156 in 3:1 ratio (1) reflecting only one chlorine atom present in the compound and isotopic ratio of 3:1 for ^{35}Cl : ^{37}Cl (1)		2				
				^{13}C NMR two peaks (1) showing two distinct environments / CF_3 and CF_2Cl (1)		2		4		
				Question 12 total	**5**	**12**	**4**	**21**	**2**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)	(i)		an atom that has four different groups or atoms bonded to it	1			1		
		(ii)		 3D representation required		1		1		
	(b)			it will react / reduce Tollens' reagent (1) giving a silver mirror (1)	2			2		2
	(c)			$m = \frac{r \times v}{[\alpha_D]} = \frac{20 \times 15}{112} = 2.68$ (g) (in 15 cm^3 solution) (1) concentration in g $dm^{-3} = \frac{2.68 \times 1000}{15} = 179$ (1)		1	1	2	2	
	(d)	(i)		(concentrated) sulfuric acid / aluminium oxide / porous pot	1			1		
		(ii)		no free rotation about the C=C double bond (1)  (1)	1	1		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)			award up to (2) marks for identification of **R** as an ester with clear reasoning • **R** contains only carbon, hydrogen and oxygen – it must be either an alcohol, an ester or a carboxylic acid (1) • **R** contains a C=O group so it cannot be an alcohol and it is neutral therefore cannot therefore be a carboxylic acid (1) award up to (4) marks for identifying **S** as $(CH_3)_3C—COOH$ • **S** is product of ester hydrolysis and weakly acidic – must be a carboxylic acid (1) • ^1H NMR signal with the relative peak area of 1 must be that of the carboxylic acid group proton at around 11δ (1) • the other 9 protons must be identical since the signal is not split – this suggests a $(CH_3)_3$ group (1) • ^{13}C spectrum shows three different carbon environments – one carbon must be in the —COOH group and the other two are in a $(CH_3)_3C—$ group (1) award up to (4) marks for identifying **T** as CH_3CH_2OH • **T** must be an alcohol (1) • ^{13}C NMR of **T** suggests ethanol and this is confirmed by ^1H NMR spectrum showing three signals of relative peak area 1:2:3 (1) • signal at 5.5δ corresponds to O—H proton, signal centred on ~4.5δ corresponds to the CH_2 protons and that at 1.4δ corresponds to the CH_3 protons (1) • splitting pattern further confirms ethanol with —CH_2 protons split by adjacent —CH_3 group giving quartet; —CH_3 protons split by adjacent —CH_2 giving triplet (1)		5	6	11		3

				• (displayed) formula of **R** is  (1)						
				Question 13 total	**5**	**8**	**7**	**20**	**2**	**5**

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	4	10	1	15	0	5
8	5	9	2	16	4	4
9	7	8	3	18	2	6
10	3	8	10	21	3	1
11	6	0	3	9	0	4
12	5	12	4	21	2	4
13	5	8	7	20	2	5
Totals	35	55	30	120	13	29