GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
CHEMISTRY – COMPONENT 3
A410U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2020 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 3

CHEMISTRY IN PRACTICE

AUTUMN 2020 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.

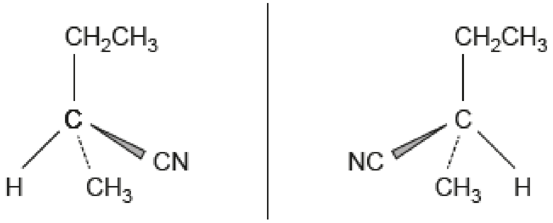
Crossed out responses not replaced should be marked.

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.

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			**D** methylpropan-2-ol (1) **H** pentanenitrile (1)	2			2		
	(b)	(i)		award (1) for correctly drawn structures of both optical isomers of $CH_3CH(CN)CH_2CH_3$ 		1		1		
		(ii)		they rotate the plane of plane polarised light in opposite directions	1			1		
		(iii)		award (1) for reagent and (1) for product e.g. (reduction with) $LiAlH_4$ (1) to form $CH_3CH(CH_2NH_2)CH_2CH_3$ (1) (hydrolysis with) HCl (1) to form $CH_3CH(COOH)CH_2CH_3$ (1) (hydrolysis with) NaOH (1) to form $CH_3CH(COONa)CH_2CH_3$ (1)		2		2		2

<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></td><td>*(c)*</td><td></td><td></td><td>
<table>
<tr><th>Compounds</th><th>Reagent(s) and condition(s)</th><th>Observation(s)</th><th>Organic compound(s) formed</th></tr>
<tr><td>$CH_3CH_2CH_2CH_2OH$
and
$CH_3CH_2CH_2CH_2Br$</td><td>acidified dichromate(VI) / heat (reflux)</td><td>orange to green solution</td><td>$CH_3CH_2CH_2CHO$
or
$CH_3CH_2CH_2COOH$</td></tr>
<tr><td>$CH_3CH_2CH_2CHO$
and
$(CH_3)_3COH$</td><td>Tollens' reagent (alkaline solution of ammoniacal silver nitrate)
warm gently in hot water bath</td><td>silver mirror</td><td>$CH_3CH_2CH_2COOH$</td></tr>
<tr><td>$CH_3CH_2CH_2COOH$
and
$CH_3CH_2CH(OH)CH_3$</td><td>I_2 / NaOH(aq)
or
KI / NaClO(aq)</td><td>yellow solid</td><td>CHI_3
and
CH_3CH_2COONa</td></tr>
<tr><td>$CH_3CH_2CH_2CH_2NH_2$
and
$CH_3CH_2CH_2CH_2CN$</td><td>nitric(III) acid (HNO_2)
room temperature</td><td>bubbles of gas</td><td>$CH_3CH_2CH_2CH_2OH$</td></tr>
</table>
award (1) for each reagent with conditions, for each observation and for each compound formed
</td><td>4</td><td>4</td><td></td><td>8</td><td></td><td>4</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		reflux in the presence of concentrated sulfuric acid	1			1		1
		(ii)		$CH_3CH_2CH_2COOH + CH_3CH_2CH(OH)CH_3 \rightleftharpoons CH_3CH_2CH_2COOCH(CH_3)CH_2CH_3 + H_2O$			1	1		
		(iii)		(addition of sodium carbonate to neutralise acid and) distillation		1		1		1
				Question 1 total	**8**	**8**	**1**	**17**	**0**	**8**

<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>**2**</td><td>*(a)*</td><td></td><td></td><td>add further sodium carbonate solution to the filtrate and no precipitate will form</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
<tr><td></td><td>*(b)*</td><td></td><td></td><td>$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>*(c)*</td><td>(i)</td><td></td><td>
<table>
<tr><th></th><th>Titration 1</th><th>Titration 2</th><th>Titration 3</th><th>Titration 4</th></tr>
<tr><td>Initial burette reading / cm^3</td><td>0.50</td><td>18.45</td><td>2.10</td><td>19.70</td></tr>
<tr><td>Final burette reading / cm^3</td><td>18.45</td><td>35.95</td><td>19.70</td><td>37.25</td></tr>
<tr><td>Titre / cm^3</td><td>17.95</td><td>17.50</td><td>17.60</td><td>17.55</td></tr>
</table>

all titres calculated and given to **2dp** (1)
mean titre 17.55 cm^3 (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td>2</td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>titration 2
smallest volume (of HCl) therefore largest percentage error</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
</table>

<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></td><td>*(d)*</td><td>(i)</td><td></td><td>
<table>
<tr><th></th><th>Correct order</th></tr>
<tr><td>Calculate the number of moles of HCl used in the titration of 25.0 cm^3 of solution **Y**</td><td>2</td></tr>
<tr><td>Calculate the number of moles of CO_3^{2-} that reacted with 200 cm^3 of solution **Y**</td><td>4</td></tr>
<tr><td>Use the balanced equation to calculate the number of moles of unreacted CO_3^{2-} in 200 cm^3 of solution **Y**</td><td>3</td></tr>
<tr><td>Calculate the concentration of the barium chloride solution in g dm^{-3}</td><td>5</td></tr>
<tr><td>Calculate the total number of moles of CO_3^{2-} added to the 50.0 cm^3 of barium chloride solution</td><td>1</td></tr>
</table>
award (1) for correct sequence
accept alternative order 1
4
2
5
3
</td><td></td><td></td><td>1</td><td>1</td><td></td><td>1</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		total mol CO_3^{2-} added = $\frac{50 \times 0.506}{1000}$ = 0.0253 (1) mol HCl in mean titre = $\frac{17.55 \times 0.200}{1000}$ = 0.00351 (1) mol unreacted CO_3^{2-} in 200 cm^3 of solution **Y** $\frac{0.00351 \times 8}{2}$ = 0.0140 (1) mol CO_3^{2-} reacted with 200 cm^3 of solution **Y** 0.0253 – 0.0140 = 0.0113 (1) [$BaCl_2$] = $\frac{0.0113}{\frac{50}{1000}}$ = 0.226 mol dm^{-3} 0.226 × 208 = 47.0 g dm^{-3} (1)		5		5	4	
		(iii)		mass $BaCO_3$ = 0.226 × $\frac{50}{1000}$ × 197 = 2.23		1		1	1	
				Question 2 total	**1**	**8**	**3**	**12**	**5**	**5**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
3	*(a)*			award (2) for any **three** of following conclusions leading to identification of **X** as magnesium award (1) for any **two** conclusions • high melting temperature of oxide and chloride ⇨ ionic compounds • basic oxide (not amphoteric) ⇨ oxide of metal • insoluble carbonate ⇨ not Group 1 metal • hydroxide and carbonate are both white ⇨ not transition metal • white precipitate with hydroxide which is insoluble in excess ⇨ Mg • no precipitate with sulfate ⇨ Mg award (1) each for **ionic** equations $\mathrm{Mg^{2+}(aq)\ +\ 2OH^{-}(aq) \rightarrow Mg(OH)_2(s)}$ $\mathrm{Mg^{2+}(aq)\ +\ CO_3^{2-}(aq) \rightarrow MgCO_3(s)}$ accept without state symbols	2		2	4		2

Question				**Marking details**	**Marks available**					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(b)			award (2) for any **three** of following conclusions award (1) for any **two** conclusions • no reaction with acids/alkalis ⇨ not a metal oxide • high melting temperature of oxide ⇨ oxide has giant molecular structure • low boiling temperature of chloride ⇨ chloride has simple covalent structure • oxide has giant molecular structure and chloride has simple covalent structure ⇨ metalloid / Group 4 element • misty fumes and white precipitate with water ⇨ Si chloride of **Y** 333 K and 1.01×10^5 Pa (1) from $pV = nRT$ $n = \frac{1.01 \times 10^5 \times 805.5 \times 10^{-6}}{8.31 \times 333} = 0.0294$ (1) $M_r = \frac{5.000}{0.0294} = 170.1$ ⇨ chloride is $SiCl_4$ / **Y** is silicon (1) award (1) for either equation $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$	1	3	2	6	3	2
				Question 3 total	**3**	**3**	**4**	**10**	**3**	**4**

Question				**Marking details**	**Marks available**					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4	*(a)*	(i)		award (1) for either of following use gas syringe to measure increase in gas volume over time measure loss in mass over time allow sample at intervals, quench and titrate [credit only in (i) or (ii)]		1		1		1
		(ii)		award (1) for basic method e.g. colorimetry / follow change in colour over time sample at intervals, quench and titrate award (2) for more detailed method e.g. follow change in colour <u>due to change in iodine concentration</u> over time sample at intervals, quench and titrate (iodine) <u>against sodium thiosulfate solution</u>		2		2		2

<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></td><td><em>(b)</em></td><td>(i)</td><td>I</td><td>award (1) for all four rates calculated
<table>
<tr><th>Expt</th><th>Rate / s^{-1}</th></tr>
<tr><td><strong>1</strong></td><td>2.98×10^{-3}</td></tr>
<tr><td><strong>2</strong></td><td>1.19×10^{-2}</td></tr>
<tr><td><strong>3</strong></td><td>2.38×10^{-2}</td></tr>
<tr><td><strong>4</strong></td><td>5.95×10^{-3}</td></tr>
</table></td><td></td><td>1</td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>II</td><td>1st order with respect to $BrO_3^-(aq)$
when $[BrO_3^-]$ doubles (expt 2 ⇨ 3), time halves / rate doubles (1)

1st order with respect to $Br^-(aq)$
when $[Br^-]$ halves (expt 2 ⇨ 4), time doubles / rate halves (1)

2nd order with respect to $H^+(aq)$
when $[H^+]$ doubles (expt 1 ⇨ 2), time reduces by a factor of 4 / rate increases by a factor of 4 (1)</td><td></td><td></td><td>3</td><td>3</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td></td><td>III</td><td>rate = $k\,[BrO_3^-][Br^-][H^+]^2$

ecf possible from part II</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
</table>

<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></td><td></td><td></td><td>IV</td><td>the sum of the powers of the reactant concentrations in the rate equation - this reaction is overall fourth order

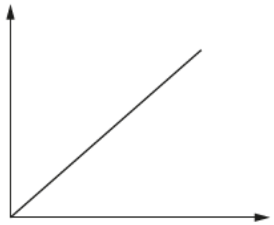
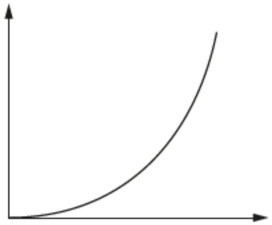
ecf possible from parts II and III</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>V</td><td>$[BrO_3^-]$, $[Br^-]$ and $[H^+]$ calculated for any of experiments <b>1-4</b> (1)

<table>
<tr><th>Expt</th><th>$[BrO_3^-]$</th><th>$[Br^-]$</th><th>$[H^+]$</th><th>Rate / s^{-1}</th></tr>
<tr><td><b>1</b></td><td>0.05</td><td>0.25</td><td>0.30</td><td>2.98×10^{-3}</td></tr>
<tr><td><b>2</b></td><td>0.05</td><td>0.25</td><td>0.60</td><td>1.19×10^{-2}</td></tr>
<tr><td><b>3</b></td><td>0.10</td><td>0.25</td><td>0.60</td><td>2.38×10^{-2}</td></tr>
<tr><td><b>4</b></td><td>0.05</td><td>0.125</td><td>0.60</td><td>5.95×10^{-3}</td></tr>
</table>

$k = \frac{rate}{[BrO_3{}^-][Br^-][H^+]^2}$ (1)

$k = 2.64$ award (2) for answer to 3 sig figs
award (1) for correct answer not to 3 sig figs

ecf possible from part III</td><td></td><td></td><td>4</td><td>4</td><td>4</td><td></td></tr>
</table>

Question				**Marking details**	**Marks available**					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
			VI	[BrO$_3^-$]  (1) [H$^+$]  (1)			2	2	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		**Indicative content** 1. Find time taken for methyl orange indicator to be bleached at a number of different temperatures 2. Initial reactant concentrations remain unchanged across all experiments 3. Calculate the rate at each temperature 4. Calculate the rate constant, *k*, at each temperature 5. Plot ln *k* against $\frac{1}{T}$ where *T* is temperature in Kelvin 6. Arrhenius equation $k = Ae^{\frac{-E_a}{RT}}$ 7. Arrhenius equation rearranged ⇨ $\ln k = \ln A - \frac{E_a}{RT}$ 8. Gradient of straight line ⇨ $m = -\frac{E_a}{R}$ 9. Calculate E_a		3	3	6	3	3

<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></td><td></td><td></td><td></td><td><b>5-6 marks</b>
Clear outline of how data is processed; good understanding of relationship between graph and Arrhenius equation
<i>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 is used accurately throughout.</i>

<b>3-4 marks</b>
Good knowledge of practical steps; basic understanding of data processing; some idea of link between graph and Arrhenius equation
<i>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.</i>

<b>1-2 marks</b>
Some knowledge of practical steps; some idea of data processing
<i>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.</i>

<b>0 marks</b>
<i>The candidate does not make any attempt or give an answer worthy of credit.</i></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td><b>Question 4 total</b></td><td><b>1</b></td><td><b>8</b></td><td><b>12</b></td><td><b>21</b></td><td><b>12</b></td><td><b>6</b></td></tr>
</table>

COMPONENT 3: CHEMISTRY IN PRACTICE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
1	8	8	1	17	0	8
2	1	8	3	12	5	5
3	3	3	4	10	3	4
4	1	8	12	21	12	6
Totals	13	27	20	60	20	23