



GCE A LEVEL MARKING SCHEME

SUMMER 2023

**A LEVEL
CHEMISTRY – COMPONENT 3
A410U30-1**

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.

GCE A LEVEL CHEMISTRY
COMPONENT 3: CHEMISTRY IN PRACTICE
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.

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)	<p>appropriate lines of best fit drawn (1)</p> <p>straight line from 5-10 minutes extrapolated back to the point of mixing giving $T_{\min} = 10.1 \pm 0.2^{\circ}\text{C}$ and $\Delta T = 9.7 \pm 0.2^{\circ}\text{C}$ (1)</p> <p>accept negative value for ΔT</p>		2		2	1	2
	(b)	<p>$n = \frac{12.38}{248.3} = 0.0499 \text{ mol}$ (1)</p> <p>$\Delta H_2 = \frac{50.0 \times 4.18 \times 9.7}{0.0499} = +40.63 \text{ kJ mol}^{-1}$ (1)</p> <p>accept any value in the range $39.79 - 41.46 \text{ kJ mol}^{-1}$ do not accept negative value for ΔH</p> <p>ecf possible from incorrect ΔT</p>		2		2	2	1
	(c)	<p>award (1) for either of following no heat is gained solid is completely dissolved</p>		1		1		1
	(d)	<p>$\Delta T = 4.85 \pm 0.1^{\circ}\text{C}$</p> <p>ecf possible from part (a)</p>			1	1		1
	(e)	<p>$-14200 = -\frac{50.0 \times 4.18 \times 3.4}{n}$</p> <p>$n = \frac{50.0 \times 4.18 \times 3.4}{14200} = 0.0500 \text{ mol}$ (1)</p> <p>mass of $\text{Na}_2\text{S}_2\text{O}_3 = 0.0500 \times 158.2 = 7.91 \text{ g}$ (1)</p>	1	1		2	1	1

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
	(f)	$\Delta H_1 = -14.2 - 40.63 = -54.83 \text{ kJ mol}^{-1}$ ecf possible from part (b)			1	1	1	
	(g)	award (1) for either of following it is not possible to prevent some of the sodium thiosulfate from dissolving other hydrates / side-products may form			1	1		
Question 1 total			1	6	3	10	5	6

Question		Marking details	Marks available						
			AO1	AO2	AO3	Total	Maths	Prac	
2	(a)	award (1) for any of following excess insoluble reactants can be separated by filtration excess acid cannot easily be removed if acid in excess it will contaminate the salt solution	1			1		1	
	(b)	add excess CuCO_3 to the acid, a little at a time, with stirring continue to add CuCO_3 until no more fizzing / solid remains filter excess unreacted CuCO_3 evaporate the filtrate (to reduce volume) / allow to crystallise award (3) for all four points award (2) for any three points award (1) for any two points	1	2		3		3	
	(c)	(i)	$n(\text{HCl}) = 0.500 \times \frac{60.0}{1000} = 0.0300 \text{ mol}$ (1) $n(\text{CuCO}_3) = 0.0150 \text{ mol}$ mass of $\text{CuCO}_3 = 0.0150 \times 123.5 = 1.85 \text{ g}$ (1)		2		2	1	
		(ii)	0.0150 mol of $\text{CuCl}_{2 \cdot x}\text{H}_2\text{O}$ formed $M_r = \frac{2.56}{0.0150} = 170.66$ (1) mass of $\text{H}_2\text{O} = 170.66 - 134.5 = 36.16$ $x = \frac{36.16}{18.02} = 2$ (1) ecf possible from part (i)		2		2	1	

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
(d)	(i)	volume used from burette is measured by difference		1		1		1
	(ii)	any drops of Na ₂ CO ₃ / HCl that splashed are washed off the sides and take part in the reaction			1	1		1
	(iii)	repeat the titration without the indicator using 25.0 cm ³ of Na ₂ CO ₃ and the titre volume of HCl		1		1		1
	(iv)	repeat to obtain concordant volumes of HCl			1	1		1
(e)	(i)	K ₂ CO ₃ + H ₂ SO ₄ → K ₂ SO ₄ + CO ₂ + H ₂ O		1		1		
	(ii)	mole ratio of Na ₂ CO ₃ : HCl is 1:2 whilst mole ratio of K ₂ CO ₃ : H ₂ SO ₄ is 1:1 (1) volume of H ₂ SO ₄ used will be half the volume of HCl therefore percentage error in burette reading will be doubled (1)			2	2		2
	(iii)	n(K ₂ CO ₃) = 0.25 × $\frac{25.0}{1000}$ = 0.00625 mol (1) n(CO ₂) = 0.00625 mol volume of CO ₂ = 0.00625 × 24.5 = 0.153 dm ³ = 153 cm ³ (1)		2		2	1	
Question 2 total			2	11	4	17	3	10

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
3		<p>Indicative content</p> <p>ACID/BASE</p> <ol style="list-style-type: none"> 1. Fe²⁺ ions react with acids 2. Iron(II) oxide is a basic oxide 3. Cr³⁺ ions react with both acids and bases 4. Chromium(III) oxide is an amphoteric oxide <p>RELEVANT EQUATIONS and OBSERVATIONS</p> <ol style="list-style-type: none"> 5. Iron(II) oxide reacts with sulfuric acid $\text{FeO} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2\text{O}$ 6. Pale green solution formed 7. Iron(II) ions formed react with a base / aqueous sodium hydroxide added dropwise $\text{Fe}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Fe}(\text{OH})_2(\text{s})$ 8. Green precipitate formed 9. Green precipitate of Fe(OH)₂ does not react / dissolve in excess aqueous sodium hydroxide 10. Chromium(III) oxide reacts with sulfuric acid $\text{Cr}_2\text{O}_3 + 3\text{H}_2\text{SO}_4 \rightarrow \text{Cr}_2(\text{SO}_4)_3 + 3\text{H}_2\text{O}$ 11. Violet-blue / green solution formed 12. Chromium(III) ions reacts with a base / sodium hydroxide added dropwise $\text{Cr}^{3+}(\text{aq}) + 3\text{OH}^{-}(\text{aq}) \rightarrow \text{Cr}(\text{OH})_3(\text{s})$ 13. Grey-green precipitate formed 14. Chromium(III) hydroxide precipitate dissolves in excess aqueous sodium hydroxide $\text{Cr}(\text{OH})_3 + 3\text{OH}^{-}(\text{aq}) \rightarrow [\text{Cr}(\text{OH})_6]^{3-}(\text{aq})$ 16. Deep green solution formed 	3	3		6		4

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
		<p>5-6 marks Both oxides correctly classified; includes most observations and several correct equations <i>The candidate constructs a relevant, coherent and logically structured account including key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.</i></p> <p>3-4 marks Both oxides correctly classified; several correct observations and good attempt at some equations <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></p> <p>1-2 marks One oxide correctly classified; includes some correct observations <i>The candidate attempts to link 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.</i></p> <p>0 marks The candidate does not make any attempt or give an answer worthy of credit.</p>						
Question 3 total			3	3	0	6	0	4

Question		Marking details		Marks available																																																	
				AO1	AO2	AO3	Total	Maths	Prac																																												
4		<p>for each product award (1) for correct starting compound and reagent(s)</p> <p>ignore conditions given in formation of B and G</p> <p>award (2) for four correct conditions</p> <p>award (1) for two correct conditions</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Starting compound</th> <th>Product</th> <th>Reagent(s)</th> <th>Conditions</th> </tr> </thead> <tbody> <tr> <td>G</td> <td rowspan="2">A</td> <td>NaOH</td> <td>aqueous solvent reflux/heat</td> </tr> <tr> <td>H</td> <td>H₂O / steam</td> <td>300°C / 60-70 atm H₃PO₄ catalyst</td> </tr> <tr> <td>H</td> <td>B</td> <td>Br₂</td> <td>liquid or aqueous bromine room temperature</td> </tr> <tr> <td>F</td> <td>C</td> <td>HNO₂ / nitric(III) acid</td> <td>room temperature</td> </tr> <tr> <td>G</td> <td>D</td> <td>KCN</td> <td>ethanol solvent reflux/heat</td> </tr> <tr> <td>H</td> <td>E</td> <td>H₂</td> <td>150°C Ni catalyst</td> </tr> <tr> <td rowspan="2">D</td> <td rowspan="2">F</td> <td>LiAlH₄</td> <td>ethoxyethane solvent</td> </tr> <tr> <td>H₂</td> <td>Pt/Pd/Ni catalyst heat</td> </tr> <tr> <td>H</td> <td>G</td> <td>HBr</td> <td>room temperature</td> </tr> <tr> <td>G</td> <td rowspan="2">H</td> <td>NaOH / KOH</td> <td>ethanol solvent reflux</td> </tr> <tr> <td>A</td> <td>conc H₂SO₄</td> <td>170°C</td> </tr> </tbody> </table>		Starting compound	Product	Reagent(s)	Conditions	G	A	NaOH	aqueous solvent reflux/heat	H	H ₂ O / steam	300°C / 60-70 atm H ₃ PO ₄ catalyst	H	B	Br ₂	liquid or aqueous bromine room temperature	F	C	HNO ₂ / nitric(III) acid	room temperature	G	D	KCN	ethanol solvent reflux/heat	H	E	H ₂	150°C Ni catalyst	D	F	LiAlH ₄	ethoxyethane solvent	H ₂	Pt/Pd/Ni catalyst heat	H	G	HBr	room temperature	G	H	NaOH / KOH	ethanol solvent reflux	A	conc H ₂ SO ₄	170°C	2	4	4	10		5
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Question 4 total				2	4	4	10	0	5																																												

Question		Marking details	Marks available						
			AO1	AO2	AO3	Total	Maths	Prac	
5	(a)	$\text{HOOC}-\text{COOH} \rightleftharpoons \text{HOOC}-\text{COO}^- + \text{H}^+ / K_{a1} = 5.62 \times 10^{-2} \text{ mol dm}^{-3}$ $\text{HOOC}-\text{COO}^- \rightleftharpoons ^-\text{OOC}-\text{COO}^- + \text{H}^+ / K_{a2} = 5.25 \times 10^{-5} \text{ mol dm}^{-3}$ award (1) for both equations correct award (1) for correct identification of K_a values with sensible attempt at explanation first proton removed from neutral molecule whilst second proton removed from a negatively charged ion therefore more difficult to remove and K_a has a smaller value (1)		1	2	3			
	(b)	(i)	$[(\text{COOH})_2] = \frac{[\text{H}^+]^2}{K_a} \quad (1)$ $0.112 = \frac{[\text{H}^+]^2}{5.62 \times 10^{-2}} \quad \Rightarrow \quad [\text{H}^+] = 0.0793 \text{ mol dm}^{-3} (1)$ $\text{pH} = -\log 0.0793 = 1.1 (1)$		3		3	3	
		(ii)	scale showing first equivalence point at 15 cm ³ and second equivalence point at 30 cm ³ (1) mole ratio n(COOH) ₂ : n(KOH) for removal of first proton is 1:1 and [(COOH) ₂] : [KOH] is in the ratio of 1:2 $\Rightarrow \quad 30 \text{ cm}^3 (\text{COOH})_2 : 15 \text{ cm}^3 \text{ of KOH for first equivalence point (1)}$		1		2	1	2

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
		alternative reasoning $n(\text{COOH})_2 = \frac{30.0 \times 0.112}{1000} = 0.00336 \text{ mol}$ mole ratio $n(\text{COOH})_2 : n(\text{KOH})$ for removal of first proton is 1:1 therefore $n(\text{KOH}) = 0.00336 \text{ mol}$ $\text{volume of KOH} = \frac{0.00336}{0.224} = 0.015 \text{ dm}^3 = 15.0 \text{ cm}^3 \text{ (1)}$						
	(c)	weak acid \Rightarrow only partially dissociated in (aqueous) solution (1) dilute acid \Rightarrow low concentration of acid molecules / H^+ ions in solution (1)	2			2		
	(d)	(i)	curve drawn has lower volume of $\text{KOH}(\text{aq})$ than original curve at both equivalence points (with one twice the volume of the other) (1) curve has slightly higher initial pH than original curve and pH at half-equivalence points for K_{a1} and K_{a2} are both the same as original curve (1)			2	2	
		(ii)	curve drawn has same volume of $\text{KOH}(\text{aq})$ as original curve at both equivalence points (1) curve has slightly higher initial pH than original curve and pH at half-equivalence points for K_{a1} and K_{a2} are both higher than in the original curve (1)			2	2	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)	(i)	indicators are weak acids or weak bases and the protonated and deprotonated species have different colours	1			1		
		(ii)	equivalence points for K_{a1} and K_{a2} are at different pH values (1) indicator colour change range must lie within the vertical range(s) of the titration curve (1)	2			2		1
Question 5 total				5	5	7	17	4	3

COMPONENT 3: CHEMISTRY IN PRACTICE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL	Maths	Practical
1	1	6	3	10	5	6
2	2	11	4	17	3	10
3	3	3	0	6	0	4
4	2	4	4	10	0	5
5	5	5	7	17	4	3
Totals	13	29	18	60	12	28