GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
CHEMISTRY – COMPONENT 3
A410U30-1

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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 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.

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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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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		appropriate lines of best fit drawn (1) straight line from 5-10 minutes extrapolated back to the point of mixing giving T_{min} = 10.1 ±0.2°C and ΔT = 9.7 ±0.2°C (1) accept negative value for ΔT		2		2	1	2
	(b)		n = $\frac{12.38}{248.3}$ = 0.0499 mol (1) ΔH_2 = $\frac{50.0 \times 4.18 \times 9.7}{0.0499}$ = +40.63 kJ mol^{-1} (1) accept any value in the range 39.79 - 41.46 kJ mol^{-1} do not accept negative value for ΔH ecf possible from incorrect ΔT		2		2	2	1
	(c)		award (1) for either of following no heat is gained solid is completely dissolved		1		1		1
	(d)		ΔT = 4.85 ±0.1°C ecf possible from part (a)			1	1		1
	(e)		–14200 = – $\frac{50.0 \times 4.18 \times 3.4}{n}$ n = $\frac{50.0 \times 4.18 \times 3.4}{14200}$ = 0.0500 mol (1) mass of $Na_2S_2O_3$ = 0.0500 × 158.2 = 7.91 g (1)	1	1		2	1	1

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(f)		ΔH_1 = –14.2 – 40.63 = –54.83 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**

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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(HCl) = $0.500 \times \frac{60.0}{1000}$ = 0.0300 mol (1) n($CuCO_3$) = 0.0150 mol mass of $CuCO_3$ = 0.0150 × 123.5 = 1.85 g (1)		2		2	1	
		(ii)	0.0150 mol of $CuCl_2.xH_2O$ formed $M_r = \frac{2.56}{0.0150}$ = 170.66 (1) mass of H_2O = 170.66 – 134.5 = 36.16 $x = \frac{36.16}{18.02}$ = 2 (1) ecf possible from part (i)		2		2	1	

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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_2CO_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_2CO_3 and the titre volume of HCl		1		1		1
		(iv)	repeat to obtain concordant volumes of HCl			1	1		1
	(e)	(i)	$K_2CO_3 + H_2SO_4 \rightarrow K_2SO_4 + CO_2 + H_2O$		1		1		
		(ii)	mole ratio of Na_2CO_3 : HCl is 1:2 whilst mole ratio of K_2CO_3 : H_2SO_4 is 1:1 (1) volume of H_2SO_4 used will be **half** the volume of HCl therefore percentage error in burette reading will be **doubled** (1)			2	2		2
		(iii)	$n(K_2CO_3) = 0.25 \times \frac{25.0}{1000} = 0.00625$ mol (1) $n(CO_2) = 0.00625$ mol volume of $CO_2 = 0.00625 \times 24.5 = 0.153\ dm^3 = 153\ cm^3$ (1)		2		2	1	
Question 2 total				**2**	**11**	**4**	**17**	**3**	**10**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3			**Indicative content** ACID/BASE 1. Fe^{2+} ions react with acids 2. Iron(II) oxide is a basic oxide 3. Cr^{3+} ions react with both acids and bases 4. Chromium(III) oxide is an amphoteric oxide RELEVANT EQUATIONS and OBSERVATIONS 5. Iron(II) oxide reacts with sulfuric acid $FeO + H_2SO_4 \rightarrow FeSO_4 + H_2O$ 6. Pale green solution formed 7. Iron(II) ions formed react with a base / aqueous sodium hydroxide added dropwise $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ 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 $Cr_2O_3 + 3H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 3H_2O$ 11. Violet-blue / green solution formed 12. Chromium(III) ions reacts with a base / sodium hydroxide added dropwise $Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$ 13. Grey-green precipitate formed 14. Chromium(III) hydroxide precipitate dissolves in excess aqueous sodium hydroxide 15. $Cr(OH)_3 + 3OH^-(aq) \rightarrow [Cr(OH)_6]^{3-}(aq)$ 16. Deep green solution formed	3	3		6		4

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			5-6 marks Both oxides correctly classified; includes most observations and several correct equations *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.* **3-4 marks** Both oxides correctly classified; several correct observations and good attempt at some equations *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** One oxide correctly classified; includes some correct observations *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.* **0 marks** The candidate does not make any attempt or give an answer worthy of credit.						
			Question 3 total	**3**	**3**	**0**	**6**	**0**	**4**

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<table>
<tr><th colspan="3" 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>4</td><td></td><td></td><td>for each product award (1) for correct starting compound and reagent(s)

ignore conditions given in formation of B and G
award (2) for four correct conditions
award (1) for two correct conditions

<table>
<tr><th>Starting compound</th><th>Product</th><th>Reagent(s)</th><th>Conditions</th></tr>
<tr><td>G</td><td rowspan="2">A</td><td>NaOH</td><td>aqueous solvent
reflux / heat</td></tr>
<tr><td>H</td><td>H_2O / steam</td><td>300°C / 60-70 atm
H_3PO_4 catalyst</td></tr>
<tr><td>H</td><td>B</td><td>Br_2</td><td>liquid or aqueous
bromine
room temperature</td></tr>
<tr><td>F</td><td>C</td><td>HNO_2 / 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>H_2</td><td>150°C
Ni catalyst</td></tr>
<tr><td rowspan="2">D</td><td rowspan="2">F</td><td>$LiAlH_4$</td><td>ethoxyethane solvent</td></tr>
<tr><td>H_2</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 H_2SO_4</td><td>170°C</td></tr>
</table>
</td><td>2</td><td>4</td><td>4</td><td>10</td><td></td><td>5</td></tr>
<tr><td colspan="4">Question 4 total</td><td>2</td><td>4</td><td>4</td><td>10</td><td>0</td><td>5</td></tr>
</table>

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		HOOC—COOH ⇌ HOOC—COO^- + H^+ / K_{a1} = 5.62 × 10^{-2} mol dm^{-3} HOOC-COO^- ⇌ $^-$OOC-COO^- + H^+ / K_{a2} = 5.25 × 10^{-5} 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)	$[(COOH)_2] = \frac{[H^+]^2}{K_a}$ (1) $0.112 = \frac{[H^+]^2}{5.62 \times 10^{-2}}$ ⇨ $[H^+]$ = 0.0793 mol dm^{-3} (1) 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 ⇨ 30 cm^3 $(COOH)_2$: 15 cm^3 of KOH for first equivalence point (1)		1	1	2	1	2

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			alternative reasoning n$(COOH)_2$ = $\frac{30.0 \times 0.112}{1000}$ = 0.00336 mol mole ratio n$(COOH)_2$: n(KOH) for removal of first proton is 1:1 therefore n(KOH) = 0.00336 mol volume of KOH = $\frac{0.00336}{0.224}$ = 0.015 dm^3 = 15.0 cm^3 (1)						
	(c)		weak acid ⇨ only partially dissociated in (aqueous) solution (1) dilute acid ⇨ low concentration of acid molecules / H^+ ions in solution (1)	2			2		
	(d)	(i)	curve drawn has lower volume of KOH(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 KOH(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		

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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**

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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**

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