GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
CHEMISTRY – COMPONENT 1
A410U10-1

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 1 – PHYSICAL AND INORGANIC CHEMISTRY

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.

Section A

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	(a)			ability of an atom to attract electron pair in a covalent bond	1			1		
	(b)			$\delta+$ $\delta-$ Si — Cl $\delta-$ $\delta+$ F — Cl both needed		1		1		
2				convergence limit of Lyman series	1			1		
3	(a)			4 half-lives (1) 6.25% (1) ecf possible		2		2	1	
	(b)			positron emission Pu 238 (1) α-emission Np 234 (1)		2		2		
4	(a)	(i)		0.020 / 0.040 / 0.081 all given to at least 2 decimal places	1			1		1
		(ii)		s^{-1}		1		1	1	
	(b)			award (1) for either of following rate is proportional to concentration of hydrogen peroxide rate is first order with respect to hydrogen peroxide		1		1	1	1

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)				1			1		
	(b)			molecule that dissociates fully releasing H^+ ions	1			1		
	(c)			$10^{-0.32} = 0.48$ mol dm^{-3}		1		1	1	
6	(a)			curve with higher maximum **and** shifted to the left	1			1		
	(b)			new E_a drawn to the left of original **and** additional molecules with energy greater than this E_a labelled	1			1		
				Total	**7**	**8**	**0**	**15**	**4**	**2**

Section B

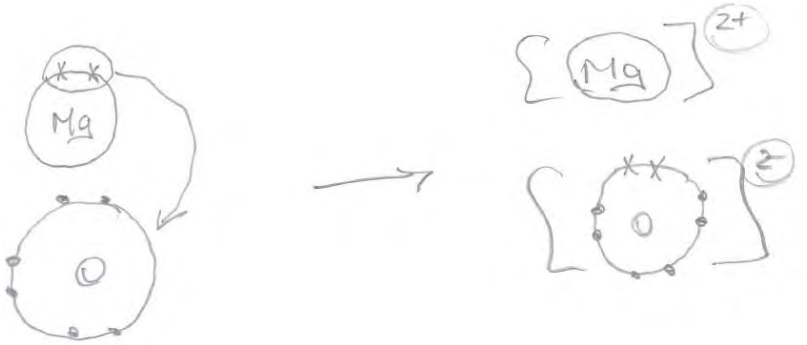
Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			**Indicative content** 1. Lead has a lattice of Pb^{2+} ions 2. In a sea of delocalised electrons 3. Carbon exists as graphite OR diamond (OR buckminsterfullerene and nanotubes) 4. Carbon forms covalent macromolecules 5. In diamond each carbon bonded to 4 other carbon atoms 6. Diamond has atoms arranged tetrahedrally 7. In graphite carbon atoms bonded to 3 others to form hexagonal layers 8. Van der Waals forces between layers 9. Delocalised electrons between layers 10. High melting temperatures for graphite/diamond as covalent bonds need to be broken 11. Diamond is an insulator as no delocalised electrons 12. Lead and graphite are conductors as the delocalised electrons can move to form a current 13. To melt lead need to overcome forces between delocalised electrons and metal ions 14. Melting point of lead is lower than carbon / lead is a solid with a melting point that is low or intermediate (for a metal) **5-6 marks** Correct description of bonding in lead and one allotrope of carbon (treat second allotrope as neutral) and linked to conductivity of both and melting temperature of carbon allotrope *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated reasoning is evident and scientific conventions and vocabulary are used accurately throughout.*	6			6		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
				3-4 marks Relatively complete description of bonding in lead and one allotrope of carbon (treat second allotrope as neutral) and correct conductivity OR melting points *The candidate constructs a coherent account including most 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 are generally sound.* **1-2 marks** Relatively complete description of bonding in lead or one allotrope of carbon *The candidate attempts to link at least three 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*						
	(b)	(i)		canary/bright yellow	1			1		1
		(ii)		$\frac{2.425}{461}$ (1) 5.26×10^{-3} mol (1)		2		2	1	2
		(iii)		$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$		1		1		1

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)		starch (1) blue-black to colourless (1)	2			2		2
		(v)		moles $S_2O_3^{2-}$ = 0.100 × 33.45 × 10^{-3} = 3.345 × 10^{-3} mol (1) moles I_2 = $\frac{3.345 \times 10^{-3}}{2}$ = 1.673 × 10^{-3} mol (1) moles PbO_2 = 1.673 × 10^{-3} mol (1)		1 1	 1 	 3	1 1	 2
		(vi)		M_r(PbO) = 223 M_r(PbO_2) = 239 (1) mass PbO_2 = 0.400 g (1) mass PbO = 223 × (5.26 × 10^{-3} – 1.673 × 10^{-3}) = 0.800 g (1) percentage by mass = 33.3% (1)		1 1 	 1 1	 4	 3	
				Total	**9**	**7**	**3**	**19**	**6**	**8**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$		1		1		
	(b)	(i)		$[CoCl_4]^{2-}$ blue (1) $[Co(H_2O)_6]^{2+}$ pink (1)	2			2		2
		(ii)		ligands split d-orbitals into three lower and two higher energy levels (1) electrons absorb specific frequencies of light to be excited from lower to higher energy levels (1) colour seen is light not absorbed / light reflected (1) do not accept 'light emitted'	3			3		
	(c)	(i)		catalyst in a different physical state to the reactants	1			1		
		(ii)		percentage CH_3OH is equal to percentage CO = $\frac{89.2}{2}$ = 44.6 % (1) P_{CH_3COOH} = 3.47 × 10^5 Pa and $P_{CH_3OH} = P_{CO}$ = 1.43 × 10^6 Pa (1) $K_p = \frac{3.47 \times 10^5}{1.43 \times 10^6 \times 1.43 \times 10^6}$ = 1.70 × 10^{-7} (1) unit = Pa^{-1} (1)		1 2	1	4	3	

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		if method 1 suggested award (1) for each of following • lower pressure so less energy needed to generate this • 100% atom economy / no waste by-products / method 2 has a lower atom economy • only one product so easier to separate / can form liquid CH_3COOH when other substances are gas phase / CH_3COOH has a higher boiling point than CO and CH_3OH so easier to condense from mixture • heterogeneous catalyst is easy to separate and reuse if method 2 suggested award (1) for each of following • uses CO_2 as a reactant and so removes a greenhouse gas • higher percentage yield of product • avoids using CO which is a toxic gas award up to 3 marks allow 2 marks for chosen method and 1 mark for other if candidate clearly shows that factors for one method outweigh those for the other			3	3		
	(d)			EMF for reaction of Cu with H^+ is –0.33 V ⇨ negative value so not feasible / SEP for Cu^{2+}/Cu is more positive than that for H^+/H_2 so Cu cannot reduce H^+ to H_2 (1) EMF for reaction of Cu with NO_3^- in acid is +0.48 V ⇨ positive value so feasible / SEP for Cu^{2+}/Cu is more negative than that for NO_3^-/NO_2 so Cu can reduce NO_3^- to NO_2 (1) award (1) for either of following $Cu + 2NO_3^- + 4H^+ \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$ $Cu + 4NO_3^- + 4H^+ \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$		1	2	3		
				Total	**6**	**5**	**6**	**17**	**3**	**2**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			 magnesium – atom with 2 electrons and ion with none (or 8) and 2+ charge (1) oxygen – atom with 6 electrons and ion with 8 electrons and 2– charge (1) it must be clear which electrons have been transferred in order to gain both marks award (1) for both ions if no other credit	2			2		
	(b)	(i)	I	small increase in temperature (so large percentage error)			1	1		1
			II	temperature would reach 100 °C / solution would boil (1) acid would no longer be in excess OWTTE (1)			2	2		2

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		$Mg + ½O_2 + 2HCl \longrightarrow MgO + 2HCl$  $MgCl_2 + H_2O$ award (1) for correct cycle or equation $\Delta H = \Delta H_{(Mg+acid)} + \Delta_f H_{(H_2O)} - \Delta H_{(MgO+acid)}$ $\Delta H = -521 + (-286) - (-142)$ (1) $\Delta H = -665$ kJ mol^{-1} (1)		3		3	2	3
	(c)	(i)		$BaCO_3$/BaO are solids which are more ordered than gases such as CO_2	1			1		
		(ii)		$\Delta S = 70 + 214 - 112 = 172$ J K^{-1} mol^{-1} (1) $T = \frac{\Delta H}{\Delta S}$ (1) award (1) for changing ΔH to J OR ΔS to kJ $T = 1413$ K (1)		4		4	3	
				Total	**3**	**7**	**3**	**13**	**5**	**6**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)	(i)		general shape of curve for exothermic reaction – products below reactants (1) activation energy ⇨ up 3/4 small squares from reactants (1) enthalpy change ⇨ down 4 large squares from reactants (1)	1	2		3	2	
		(ii)		units of activation energy changed ⇨ 18000 J mol^{-1} (1) Method 1 calculate A as 3.704×10^7 (1) $T = \frac{-E_a}{R \ln\left(\frac{2k}{A}\right)}$ or other suitable expression for T (1) T = 240 K (1) Method 2 rate at temp T = 2 × rate at 223K $Ae^{-E_a/RT} = 2 \times Ae^{-E_a/223R}$ (1) $e^{-18000/8.31T} = 2 \times e^{-18000/223 \times 8.31}$ (1) T = 240 K (1)		1 1 1	1 1	4	4	
		(iii)	I	rate = $k[Cl_2][O_3]$		1		1		
			II	mol^{-1} dm^3 s^{-1}	1			1	1	

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)		$Cl_2(g)$ is an element in its standard state so enthalpy of formation is zero (1) ozone / O_3 is not the standard state for oxygen (1)	1	 1		 2		
		(v)		moles Cl_2O_7 = $\frac{2.70}{183}$ = 1.475×10^{-2} mol (1) each Cl_2O_7 forms 4½ mol of gas on decomposition 6.64×10^{-2} mol of gas (1) award (1) for temperature factor $\frac{261}{298}$ or rearranged expression $V = \frac{nRT}{p}$ volume = 1.43 dm^3 (1)		 4		 4	 3	
	(b)			3.0 g dm^{-3} (1) $\frac{3.0}{67.5}$ = 4.4×10^{-2} mol dm^{-3} (1)	1	 1		 2	 1	
	(c)	(i)		+7	1			1		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		chlorine has two isotopes ^{35}Cl and ^{37}Cl present in 3:1 ratio (1) peaks at 134 ($^{35}ClO^{35}ClO_3$), 136 ($^{35}ClO^{37}ClO_3$) and 138 ($^{37}ClO^{37}ClO_3$) (1) peak at 134 is 9 times height of peak at 138 ⇨ ratio of $3^2:1^2$ (1) peak at 136 is 6 times peak at 138 ⇨ ratio of [3 × 1 ($^{35}ClO^{37}ClO_3$)] + [1 × 3 ($^{37}ClO^{35}ClO_3$)] :1 (1)	1		3	4	2	
	(d)			Cl has two lone pairs as well as two bonded pairs (1) bonded pairs repelled by lone pairs / ion is V-shaped (like water) / structure is based on a tetrahedral structure (1)		2		2		
				Total	**6**	**13**	**5**	**24**	**13**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			**Indicative content** 1. HA is weak acid / HB is strong acid 2. pH of HA is higher than pH of HB early in titration / after adding 5/10/15 cm^3 NaOH so fewer H^+ ions (ignore reference to INITIAL pH as this is not shown) 3. Vertical region of curve of HA is shorter than HB 4. So equivalence point at a higher pH for HA 5. HA shows a flattening at around 15 cm^3 NaOH due to buffer effect 6. HA is more concentrated than HB 7. More NaOH needed to neutralise HA than HB 8. 30 cm^3 needed for HA and 21.00-21.50 cm^3 needed for HB **5-6 marks** Correct acids identified in terms of strength and concentration; full explanation of both *The candidate constructs a relevant, coherent and logically structured method 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** Correct acids identified in terms of strength and concentration; some reasons given for both *The candidate constructs a coherent account including most 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 are generally sound.*		4	2	6	2	4

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
				1-2 marks Stronger acid or more concentrated acid identified with relevant reason given *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.*						
	(b)			at half-neutralisation point of HA pH = 5.6 (1) accept 5.5-5.7 $K_a = 10^{-5.6} = 2.51 \times 10^{-6}$ mol dm^{-3} (1) accept 2.00×10^{-6} - 3.16×10^{-6} mol dm^{-3}			2	2	2	
	(c)			indicators must change colour in a vertical region of the curve (1) titrations of HA and HB both have a vertical region but a weak acid-weak base titration does not (1)	2			2		2
	(d)	(i)		mol NaOH = 0.250 × 0.150 = 0.0375 mol (1) mass = 0.0375 × 40.01 = 1.50 g (1)		2		2		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		place NaOH in a beaker and add a small amount of deionised water to dissolve (1) transfer to volumetric flask and rinse beaker/glass rod/funnel several times with all washings going into the flask OWTTE (1) add deionised water up to line, put stopper on and invert several times to mix thoroughly (1)	3			3		3
		(iii)		$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.00 \times 10^{-14}}{0.150}$ (1) $[H^+] = 6.67 \times 10^{-14}$ (1) $pH = -\log[H^+] = 13.2$ (1)		3		3	3	
				Total	**5**	**9**	**4**	**18**	**7**	**9**

<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>12</td><td>(a)</td><td></td><td></td><td>award (2) for all five correct
award (1) for any three correct

<table>
<tr><th>Value of ionisation energy / kJ mol^{-1}</th><th>Letter representing the ionisation energy</th></tr>
<tr><td>84 078</td><td>C</td></tr>
<tr><td>64 360</td><td>B</td></tr>
<tr><td>2372</td><td>A</td></tr>
<tr><td>1450</td><td>E</td></tr>
<tr><td>496</td><td>D</td></tr>
</table>

accept references to names or letters for the ionisation energies in explanation

first IE of helium, final IE of nitrogen and oxygen (A, B, C) are the largest values because they have no shielding (1)

oxygen > nitrogen > helium (C > B > A) because oxygen has the largest nuclear charge and helium the smallest (1)

ions resulting from 1st ionisation of sodium and 2nd ionisation of magnesium (D and E) have same electronic structure but greater charge on nucleus of magnesium means that E is the higher (1)</td><td></td><td></td><td>5</td><td>5</td><td></td><td></td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			boiling temperature of NH_3 –33 °C boiling temperature of PH_3 –132 °C boiling temperature of AsH_3 –111 °C award (1) for all three correct NH_3 is the only compound with hydrogen bonding between molecules and as this is the strongest intermolecular force, this compound has the highest boiling temperature (1) PH_3 and AsH_3 have van der Waals' forces between molecules; AsH_3 has more electrons meaning more interactions and therefore the higher boiling point (1)		3		3		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			**W** barium hydroxide **X** lead nitrate – accept lead ethanoate **Y** copper(II) sulfate **Z** sodium iodide award (3) for **all** correct award (2) for any **six** correct ions award (1) for any **three** correct ions award (1) each for up to **three** of following • colours golden yellow flame test ⇨ Na^+ apple green flame test ⇨ Ba^{2+} pale blue solution ⇨ $Cu^{2+}(aq)$ • white precipitate is CuI and brown solution contains $I_2(aq)$ so **Y** and **Z** must contain Cu^{2+} and I^- • white precipitate dissolving when excess **W** is added shows an amphoteric metal ion reacting with hydroxide so **X** contains Pb^{2+} and **W** contains OH^- • mixture of pale blue precipitate and white precipitate is $Cu(OH)_2$ and $BaSO_4$		2	4	6		6
				Total	**0**	**5**	**9**	**14**	**0**	**6**

COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL	Maths	Practical
Section A	7	8	0	**15**	4	2
7	9	7	3	**19**	6	8
8	6	5	6	**17**	3	2
9	3	7	3	**13**	5	6
10	6	13	5	**24**	13	0
11	5	9	4	**18**	7	9
12	0	5	9	**14**	0	6
Totals	**36**	**54**	**30**	**120**	**38**	**33**