GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
CHEMISTRY – UNIT 3
1410U30-1

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 UNIT 3

PHYSICAL AND INORGANIC CHEMISTRY

SUMMER 2023 MARK SCHEME

GENERAL INSTRUCTIONS

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					
					Total	AO1	AO2	AO3	Maths	Prac
1.				$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$	1	1				1
2.				enthalpy of solution = (–464) + (–364) – (–905) = 77 kJ mol^{-1} (1) enthalpy of solution is positive/endothermic so it is insoluble (1) alternative method enthalpy of hydration = –828 kJ mol^{-1} (1) enthalpy of lattice formation is more exothermic so it is insoluble (1)	2	1	1			
3.				metal ion is lithium as it gives a red flame test (1) anion is iodide as it gives purple fumes (of iodine) / rotten egg smell (of hydrogen sulfide) (1)	2		1 1			1 1
4.				Al is electron deficient / does not have a full outer shell (1) lone pair on Cl (1)	2	1 1				
5.				royal blue	1	1				1
6.				catalyst in a different physical state to the reactants	1	1				
7.				boron nitride doesn't conduct electricity but graphite does must name both substances or state that 'only' graphite conducts electricity	1	1				
					10	**7**	**3**	**0**	**0**	**5**

SECTION B

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
8.	(a)			moles of $K_2Cr_2O_7$ = 0.017 mol dm^{-3} (1) concentration = $\frac{0.017}{0.250}$ = 0.0680 mol dm^{-3} (1) ecf possible from incorrect M_r	2		1 1			
	(b)	(i)		$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	1	1				
		(ii)		$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$ do not accept equation with electrons included	1		1			1
		(iii)	I	starch	1	1				1
			II	Moles dichromate = 0.0680 × $\frac{25}{1000}$ = 1.70×10^{-3} mol (1) $1Cr_2O_7^{2-} \equiv 3I_2 \equiv 6S_2O_3^{2-}$ so moles thiosulfate = 6 ×1.70×10^{-3} = 0.0102 mol (1) concentration = $\frac{0.0102}{\frac{24.30}{1000}}$ = 0.420 mol dm^{-3} (1) ecf possible from incorrect stoichiometry in equation in (b)(ii)	3		1 1	1	1 1	1 1 1

Question				**Marking details**	**Marks Available**					
					Total	**AO1**	**AO2**	**AO3**	**Maths**	**Prac**
	(c)			orange to yellow (1) oxidation state is +6 in both $Cr_2O_7^{2-}$ and CrO_4^{2-} / doesn't change from $Cr_2O_7^{2-}$ to CrO_4^{2-} ((1) neutral answer – there is no reduction or oxidation	2	1 1				1 1
	(d)	(i)		4 × (–1382) + 2 × (–1128) + 3 (0) – 4 $\Delta_f H^\theta$= 348 (1) $\Delta_f H^\theta$ = –2033 kJ mol^{-1} (1) ecf possible	2		1 1		1	
		(ii)		$T = \frac{\Delta H}{\Delta S} = \frac{348000}{385}$ (1) T = 904 K (1) ecf possible	2		1 1		1	
					14	**4**	**7**	**3**	**3**	**7**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>Total</th><th>AO1</th><th>AO2</th><th>AO3</th><th>Maths</th><th>Prac</th></tr>
<tr><td>9.</td><td>(a)</td><td></td><td></td><td>Indicative content

1. Oxidation states in Group 4 are stable at +4 at the top of the group and +2 at the bottom
2. Due to the inert pair effect
3. The inert pair effect increases down the group
4. PbO more stable than PbO_2 / PbO_2 is an oxidising agent / CO_2 more stable than CO / CO is a reducing agent
5. SiO doesn’t form as this is a +2 oxidation state which cannot form this high in the group
6. +5 oxidation state possible in third period of Group 5 but not in Period 2
7. This is because phosphorus can expand its octet / phosphorus has available d-orbitals
8. NCl_5 not possible as N has no available d-orbitals so it cannot expand its octet
9. One characteristic of transition metals is that they form a variety of oxidation states
10. Mn can form a range of oxidation states as the 3d orbitals (and 4s) have similar energies and similar ionisation energies

5-6 marks: At least seven relevant points, discussing the oxidation states of all three sets of elements
<i>The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content, clearly showing an understanding of the reasons for the differing oxidation states in all three categories. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.</i></td><td>6</td><td>4</td><td>2</td><td></td><td></td><td></td></tr>
</table>

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
				3-4 marks: At least five relevant points, discussing the oxidation states of two sets of elements *The candidate constructs a coherent account including most of the key elements of the indicative content and little irrelevant material, explaining at least one of the inert pair effect or octet expansion. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks:** Two or three relevant points, discussing the oxidation states of any of the elements *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, however there is some understanding of the patterns in oxidation states. 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)		rate = k [Pt^{4+}] [Sn^{2+}]	1		1			
		(ii)		(rate constant is large so) the reaction is very fast has a high rate (1) reaction would be complete / most would have reacted in 30 seconds (1)	2			1 1		1 1
	(c)	(i)		frequency that is absorbed by one reactant only but not by its product (or vice versa) accept ‘frequency absorbed by only one species’	1		1			1

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
		(ii)		gradient = –1.60 × 10^3 (allow range –1.57 to –1.63) (1) gradient = $\frac{-E_a}{R}$ (1) E_a = 13.3 kJ mol^{-1} (allow range 13.0-13.5) (1)	3		1	1 1	1 1 1	
					13	**4**	**5**	**4**	**3**	**3**

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
10.	(a)			student is correct because to find the minimum temperature they need ΔS and ΔH / they need to be able to calculate ΔG (1) they can calculate ΔH for both as standard enthalpy changes of elements in standard states are zero OR ΔH for decomposition is reverse of enthalpy change of formation (1) they can calculate ΔS for F_2O but not Cl_2O as we don't know entropy of Cl_2 OR entropy value of elements is not zero (1)	3			1 1 1		
	(b)	(i)		$2F_2O + Xe \rightarrow XeF_4 + O_2$	1	1				
		(ii)		xenon oxidation state changes from 0 to +4	1		1			
	(c)	(i)		$n(O_2) = \frac{pV}{RT} = \frac{1.01 \times 10^5 \times 82 \times 10^{-6}}{8.31 \times 288} = 3.46 \times 10^{-3}$ mol (1) $[HF] = \frac{2 \times 3.46 \times 10^{-3}}{0.400} = 0.0173$ mol dm^{-3} (1)	2		1 1		1	
		(ii)		$K_a = \frac{[H^+][F^-]}{[HF]}$ so $[H^+]^2 = K_a \times [HF]$ (1) $[H^+]^2 = 6.6 \times 10^{-4} \times 0.0173 = 1.14 \times 10^{-5}$ so $[H^+] = 3.38 \times 10^{-3}$ mol dm^{-3} (1) pH = 2.47 / 2.5 (1) ecf possible from part (i)	3		1 1 1		1 1 1	

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
	(d)	(i)		$K_c = \frac{[HOCl]^2}{[Cl_2O][H_2O]}$	1	1				
		(ii)	I	$[H_2O]$ at equilibrium = 0.29 mol dm^{-3} (1) $[Cl_2O]$ at equilibrium = 0.03 mol dm^{-3} (1) K_c = 5.56 (1) ecf possible from incorrect *p* expression	3		1 1	1	1 1 1	
			II	at a higher temperature K_c is larger so equilibrium has shifted to the right (1) reaction is endothermic (1) ecf possible from incorrect K_c value	2		1 1			
			III	Tl^+ and Fe^{2+} (1) SEP for HClO is more positive than for these half-cells so can oxidise the ions OR positive EMF values calculated for the reactions (1)	2		1 1			
					18	**2**	**12**	**4**	**7**	**0**

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<tr><td>11.</td><td>(a)</td><td></td><td></td><td>award (1) for either of following
a molecule that partially dissociates to release/donate H^+
a molecule that releases H^+ in a reversible reaction</td><td>1</td><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>award (1) each for calculating K_a or pK_a or pH for two acids
<table>
<tr><th></th><th>K_a / mol dm^{-3}</th><th>pK_a</th><th>pH</th></tr>
<tr><td>X = H</td><td>1.32×10^{-5}</td><td>4.88</td><td>2.59</td></tr>
<tr><td>X = Cl</td><td>1.48×10^{-3}</td><td>2.83</td><td>1.57</td></tr>
<tr><td>X = OH</td><td>1.38×10^{-4}</td><td>3.86</td><td>2.08</td></tr>
</table>
X = H < X = OH < X = Cl (1)
ecf possible from calculated values</td><td>3</td><td></td><td>1</td><td>1
1</td><td>2</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td></td><td>$[H^+] = \frac{K_w}{[OH^-]} = 1.25 \times 10^{-14}$ mol dm^{-3} (1)
pH = 13.9 (1)
ecf possible from incorrect $[H^+]$</td><td>2</td><td></td><td>2</td><td></td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>concentration of salt = concentration of acid so pH = pK_a (1)
pH = 4.74 (1)</td><td>2</td><td></td><td>1</td><td>1</td><td>2</td><td></td></tr>
</table>

Question				**Marking details**	**Marks Available**					
					Total	**AO1**	**AO2**	**AO3**	**Maths**	**Prac**
		(iii)		$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ (1) award (1) each for any **two** of following • $CH_3COONa \rightarrow CH_3COO^- + Na^+$ • addition of small amount of H^+ - this shifts equilibrium to left to remove H^+ • addition of small amount of OH^- - this removes H^+ and shifts equilibrium to right to produce more H^+	3	3				
					11	**4**	**4**	**3**	**6**	**0**

Question				**Marking details**	**Marks Available**					
					Total	**AO1**	**AO2**	**AO3**	**Maths**	**Prac**
12.	(a)			$\frac{1.44}{18.02}$ = 0.080 mol (1) e = $\frac{0.080}{0.020}$ = 4 (1)	2		1	1	1	
	(b)			$\frac{\frac{490}{1000}}{24.5}$ = 0.020 (1) c = $\frac{0.020}{0.020}$ = 1 (1)	2		1	1	1	
	(c)			white part of precipitate caused by $Mg(OH)_2$ produced from Mg^{2+} ions (1) grey-green precipitate so X is chromium/Cr (1) precipitate dissolves because Cr^{3+} is amphoteric (1)	3	1 1		1		1 1 1
	(d)			moles of HCl added = $\frac{25}{1000}$ × 1.00 = 0.025 mol (1) moles of NaOH required to neutralise remaining acid = $\frac{14}{1000}$ × 0.500 = 0.007 mol moles of HCl remaining = 0.007 mol (1) moles of HCl reacting with OH^- and CO_3^{2-} = 0.025 – 0.007 = 0.018 mol (1) Moles of HCl reacting with OH^- = 0.018–0.002 = 0.016 mol d = $\frac{0.016}{0.001}$ = 16 (1) ecf possible from part (b) for final mark	4		1	1 1 1	1 1 1	1 1

Question				Marking details	Marks Available					
					Total	AO1	AO2	AO3	Maths	Prac
	(e)			award (3) for correct answer ⇨ $Mg_6Cr_2(CO_3)(OH)_{16}.4H_2O$ if correct answer not given award (1) for transferring identity of X and all numbers from parts (a)-(d) award (1) for balanced charges award (1) for 56 atoms present	3			1 1 1		
					14	**2**	**3**	**9**	**5**	**5**

	TOTAL	AO1	AO2	AO3	Maths	Prac
Section A	**10**	7	3	0	0	5
8	**14**	4	7	3	3	7
9	**13**	4	5	4	3	3
10	**18**	2	12	4	7	0
11	**11**	4	4	3	6	0
12	**14**	2	3	9	5	5
	80	**23**	**34**	**23**	**24**	**20**