GCE A LEVEL MARKING SCHEME

SUMMER 2022

A LEVEL
CHEMISTRY – UNIT 3
1410U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2022 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 2022 MARK SCHEME

GENERAL INSTRUCTIONS

<u>Extended response questions</u>

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.

<u>Marking rules</u>

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.

<u>Marking abbreviations</u>

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)			bright yellow / canary yellow	1			1		
	(b)			$Pb^{2+} + 2I^{-} \rightarrow PbI_2$	1			1		
2				$[CuCl_4]^{2-}$	1			1		
3	(a)			rate = $k[N_2O_5]$	1			1		
	(b)			accept any balanced equation that has one N_2O_5 as reactant e.g. $N_2O_5 \rightarrow NO_2 + NO + O_2$		1		1		
4				potential difference/EMF measured when a half-cell is connected to the standard hydrogen electrode (1) award (1) for any **two** of the standard conditions 298 K temperature 1 atm pressure 1 mol dm^{-3} concentration	2			2		
5				award (1) for either of following phosphorus can expand octet but nitrogen cannot phosphorus has available d-orbitals (so can have more than 8 electrons in outer shell in molecules) but nitrogen does not answer **must** refer to both elements	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6				$K_w = [H^+][OH^-]$	1			1		1
7				particles have greater freedom in liquid mercury compared to solid gold (so they have less order in liquid and higher entropy)	1			1		
				Section A total	**9**	**1**	**0**	**10**	**0**	**1**

Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	(a)			layers/sheets of hexagons of C atoms bonded together (1) weak forces between layers (allowing layers to move and making it soft) (1)	2			2		
	(b)	(i)		121 kJ mol^{-1}	1			1		
		(ii)		enthalpy of atomisation for Cl is 121 (1) correctly constructed energy cycle or expression e.g. $\Delta_f H$(NaCl) = $\Delta_{at} H$(Na) + IE(Na) + ½BE(Cl_2) + EA(Cl) + $\Delta_{latt} H$(NaCl) (1) $\Delta_{latt} H$(NaCl) = –771 kJ mol^{-1} (1)		3		3	2	
		(iii)		student is incorrect must consider entropy of surroundings as well / must consider effects of enthalpy on entropy of surroundings / Gibbs free energy must be considered (must be negative and this includes enthalpy and entropy) (1) award (1) for either of following entropy change for this reaction will be negative as gas is removed entropy change will be negative as entropy of chlorine / gaseous reactant is greater than entropy of product		1	1	2		

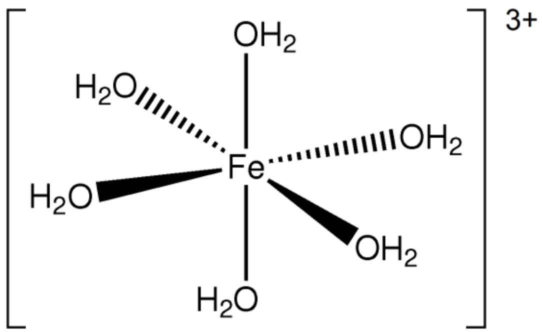
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>Indicative content
• brick red flame – one of the metals must be calcium
• no other colour – other metal may be magnesium / cannot be lithium/sodium/strontium/barium (ignore references to potassium unless clearly indicated that colour is weak and could be hidden by colour due to calcium)
• cloudiness with dilute sulfuric acid due to calcium sulfate being sparingly soluble (but no precipitate so no strontium/barium present)
• precipitate with silver nitrate – X must be chloride/bromide/iodide
• misty fumes with sulfuric acid are hydrogen halides
• no coloured fumes so must be chloride
• M_r of water is 216.27 so d = $\frac{216.27}{18.02}$ = 12
• M_r of anhydrous solid is 301.73
• formula must be $CaMg_2Cl_6.12H_2O$
(allow without H_2O as long as $12H_2O$ has been clearly calculated earlier)

5-6 marks
The candidate includes at least six relevant points and correctly identifies the formula
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 is used accurately throughout.

3-4 marks
The candidate includes at least four relevant points and correctly identifies all ions present
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
The candidate includes at least three relevant points
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.</td><td>2</td><td>2</td><td>2</td><td>6</td><td>1</td><td>5</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 8 total</td><td>5</td><td>6</td><td>3</td><td>14</td><td>3</td><td>5</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 (4s^0)$ (1) partially-filled d-orbitals (1)	 1	1		2		
	(b)			award (1) for either of following the energy of the (4s and) 3d-orbitals are all similar the ionisation energies to remove the (4s and) 3d-electrons are similar	1			1		
	(c)			 must show clear octahedral structure with bonds between Fe and O atoms in water	1			1		
	(d)	(i)		different ligands cause different amount of d-orbital splitting (1) so different frequencies/wavelengths of light are absorbed (and different frequencies/wavelengths are transmitted/reflected) (1)	1	 1		2		
		(ii)		find a wavelength absorbed by $[Fe(H_2O)_6]^{3+}$ but not by $[Fe(H_2O)_5(OH)]^{2+}$ / any other species in the mixture		1		1		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		$K_c = \frac{[H^+][\{Fe(H_2O)_5(OH)\}^{2+}]}{[\{Fe(H_2O)_6\}^{3+}]}$ (1) unit ⇨ mol dm^{-3} (1)		1 1		2	1	
		(iv)		$[H^+]$ = 0.0282 mol dm^{-3} (1) $[Fe(H_2O)_6]^{3+} = \frac{0.103 \times 0.0282}{4.03 \times 10^{-3}}$ (1) $[Fe(H_2O)_6]^{3+}$ = 0.720 (1) mass of $FeCl_3.6H_2O$ = (0.720 + 0.103) × 270.4 = 222.5g (1)		1	3	4	3	
	(e)	(i)		$[Fe(H_2O)_3(OH)_3]$ or $Fe(OH)_3$ brown / red-brown / dark brown formula **and** colour needed	1			1		1
		(ii)		oxygen (from the air) can oxidise Fe^{2+} to Fe^{3+} (turning the precipitate brown) (1) award (1) for either of following • because oxygen has a more positive standard electrode potential than Fe^{3+} so it is a stronger oxidising agent • the EMF for the reaction between O_2 and Fe^{2+} is positive / +0.46V and positive reactions are feasible		1	1	2		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		electrode potential will be less positive / more negative (1) **must** attempt reason to gain this mark alkaline solution will reduce concentration of H^+ so equilibrium will move to left (1)			2	2		
	(f)	(i)		$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$		1		1		
		(ii)		CO has carbon in +2 oxidation state but the stable oxidation state of carbon is +4	1			1		
				Question 9 total	**6**	**8**	**6**	**20**	**4**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			bromothymol blue **and** naphtholphthalein (1) change colour completely within vertical range of curve (1)	1	1		2		2
	(b)			moles NaOH = $20.0 \times \frac{0.250}{1000}$ = 5.00×10^{-3} (1) [HA] = $\frac{5.00 \times 10^{-3}}{25.0 \times 10^{-3}}$ = 0.200 mol dm^{-3} (1)		2		2	1	2
	(c)			pK_a = pH at half neutralisation = 3.85 (± 0.1) (1) K_a = 1.41×10^{-4} mol dm^{-3} (1) ECF possible for any value in the range 1.12×10^{-4} to 1.78×10^{-4} $[H^+]^2 = K_a \times [HA] = 2.83 \times 10^{-5}$ (1) ECF possible for any value in the range 2.24×10^{-5} to 3.56×10^{-5} pH = 2.27 (1) ECF possible for any value in the range 2.22 to 2.32		1 1	1 1	4	3	
	(d)			award (1) for any of following storing/using enzymes (at constant pH) fermentation dyeing accept any other sensible use	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)			award (1) for rearranged equation T = $\frac{\Delta H - \Delta G}{\Delta S}$ T = 307 K (1) process is exothermic / enthalpy change is negative so when temperature increases equilibrium shifts to the left (1) accept converse answer if temperature calculated is below 298K		1 (total 1)	2	3	2	
				Question 10 total	**2**	**6**	**4**	**12**	**6**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)	(i)		6.45 cm^3		1		1		
		(ii)		moles thiosulfate = 0.500 × $\frac{6.45}{1000}$ = 3.225 × 10^{-3} mol (1) reaction ratio ⇨ $2S_2O_3^{2-} \equiv 1I_2 \equiv 1\ ClO^-$ so moles chlorate(I) = 1.6125 × 10^{-3} mol (1) concentration chlorate(I) = $\frac{1.6125 \times 10^{-3}}{25 \times 10^{-3}}$ × 10 = 0.645 mol dm^{-3} (1) ecf possible from part (i)		3		3	2	
		(iii)		0.645 × $\frac{74.5}{10}$ = 4.81 %		1		1	1	
		(iv)		should have chosen 0.200 mol dm^{-3} marks credited for reasons, MAX 1 mark for reasons if a different concentration is chosen use a lower concentration so titration volume is greater – smaller percentage error / more accurate (1) cannot use too low a concentration / 0.0500 mol dm^{-3} as volume would be too large (for a standard burette) (1)			2	2		2
	(b)	(i)	I	order with respect to ClO_3^- ⇨ first order (1) order with respect to Br^- ⇨ first order (1) must show working to gain each mark		2		2	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
			II	pH 1 has H^+ conc^n of 0.1 mol dm^{-3} / 10 times smaller than pH 0 (1) rate is 10^3 times lower rate = $\frac{9.18 \times 10^{-7}}{10^3}$ = 9.18×10^{-10} mol dm^{-3} s^{-1} (1)		1	1	2	2	
		(ii)		award (1) for each of following $e^{\frac{-52800}{308R}} = 1.0986 \times 10^{-9}$ $e^{\frac{-52800}{298R}} = 5.4981 \times 10^{-10}$ 1.0986×10^{-9} is double 5.4981×10^{-10} / $\frac{1.0986 \times 10^{-9}}{5.4981 \times 10^{-10}} = 2$ therefore the rule is true under these conditions (1) or award (1) for each of following k at 298 = 5.1×10^{-6} k at 308 = 1.02×10^{-5} value of k at 308K is double its value at 298K therefore the rule is true under these conditions (1) ECF possible from incorrectly calculated values		1 1	1	3	3	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		K_a of stronger acid would be <u>greater</u> than that for weaker acid as stronger acids have <u>greater dissociation</u>	1			1		
		(ii)	I	Joe's method: rearrangement of pV = nRT (1) n = 3.5×10^{-3} (1) accept alternative method Heledd's method: n = 3.48×10^{-3} or 3.484×10^{-3} (1) must show use of M_r of carbon dioxide to gain mark both answers to **appropriate** significant figures and both concentrations are the same (ECF from calculations) (1)		1 1 1	1	4	3	1
			II	Heledd's method as measurements are to more significant figures / more precise / have higher resolution			1	1		1
			III	would make Heledd's experiment less accurate as the mass released would be much smaller (as H_2 has much smaller M_r than CO_2) (1) will not affect the accuracy of Joe's experiment as same volume of gas would be produced (1)			1 1	2		
		(iii)		pH from 2-6 (1) **must** attempt reason to gain this mark award (1) for either of following ammonium ion (partially) dissociates to release H^+ ions $NH_4^+ \rightleftharpoons NH_3 + H^+$ do not accept compound/salt/ammonium perchlorate releases H^+	1	1		2		
				Question 11 total	**2**	**14**	**8**	**24**	**13**	**4**

UNIT 3: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	9	1	0	10	0	1
8	5	6	3	14	3	5
9	6	8	6	20	4	3
10	2	6	4	12	6	4
11	2	14	8	24	13	4
Totals	24	35	21	80	26	17