GCE A LEVEL MARKING SCHEME

AUTUMN 2021

A LEVEL
CHEMISTRY - COMPONENT 1
A410U10-1

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INTRODUCTION

This marking scheme was used by WJEC for the 2021 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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COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

AUTUMN 2021 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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Section A

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1				chlorine kills bacteria / sterilizes water do not accept any reference to cleaning water	1			1		
2				graphite has delocalised electrons (between layers) that can move and carry a current	1			1		
3				ethanoic acid as highest pK_a means lowest K_a (so it is the least dissociated)			1	1	1	
4				$K_p = \frac{p(PCl_3) \times p(Cl_2)}{p(PCl_5)}$(1) $p(PCl_3) = p(Cl_2) = 70$ kPa / 70000 Pa (1) K_p = 49000 Pa (1)	1	1 1		3	2	
5	*(a)*			award (1) for either of following measure volume of gas produced over time measure change of mass over time	1			1		1
	(b)			first order with respect to both $NaHCO_3$ and HCl (1) rate = k $[NaHCO_3]^1[HCl]^1$ (1) accept rate = k $[NaHCO_3]$ [HCl]		2		2	1	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6				award (2) for correct equation $2C(s) + 3H_2(g) + ½O_2(g) \rightarrow C_2H_5OH(l)$ award (1) if state symbols incorrect or omitted	 1	1		2		
7				$k = Ae^{-E_a/RT}$ (1) k = 0.497 (1)	1	1		2	2	
8	*(a)*			oxygen has (two) lone pairs which repel more than bonded pairs	1			1		
	(b)			award (1) for either of following sulfur can expand its octet whilst oxygen cannot sulfur has d-orbitals in its outer shell but oxygen does not	 1			1		
				Section A total	**8**	**6**	**1**	**15**	**6**	**1**

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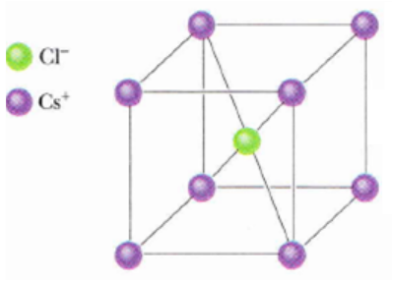
Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*			outer electron in a higher shell (further from nucleus) (1) with greater shielding from inner electrons (outweighing the increased nuclear charge) (1)	2			2		
	(b)			percentage Cs = $\frac{133}{M_r}$ ⇨ $M_r = \frac{133}{0.2416}$ (1) M_r = 550.5 (1)		2		2	1	
	(c)	(i)		 must be labelled as Cs^+ and Cl^- or caesium and chloride <u>ions</u> do not accept Cs and Cl or any reference to atoms	1			1		
		(ii)		caesium ion is much larger than sodium ion (so can accommodate more chloride ions around it)	1			1		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		xenon/Xe 131		1		1		
		(ii)		high-energy electrons	1			1		
		(iii)		32 days is 4 half-lives (1) $\frac{8.5 \times 10^{16}}{16}$ = 5.3×10^{15} (1)		1 1		2	1	
		(iv)		caesium-137 (1) must attempt reason to gain mark it has a (slightly) lower level of radioactivity however it has a much longer half-life, so much greater amounts of caesium-137 must have been released to produce this level of radioactivity (1)			2	2		
				Question 9 total	**5**	**5**	**2**	**12**	**2**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*			solution that keeps pH (relatively) constant upon addition of small amounts of acid or base	1			1		
	(b)			award (1) for any of following storing enzymes fermentation (in baking/brewing) dyeing	1			1		
	(c)	(i)		moles of propanoic acid = 1.00 × $\frac{100}{1000}$ = 0.100 mol (1) M_r of sodium propanoate = 23 + 36 + 32 + 5.05 = 96.05 (1) mass of sodium propanoate = 9.605 g (1) pH = 4.87 (1) accept any value in the range 4.86-4.88		1 1 1 1		4	3	
		(ii)		pK_a = pH when [acid] = [salt] ⇨ $K_a = 10^{-pH}$ at this point (1) $K_a = 1.34 \times 10^{-5}$ (1) accept any value in the range 1.32-1.38 × 10^{-5}		1	1	2	2	
		(iii)		since $[H^+] = K_a \times \frac{[acid]}{[salt]}$, if more salt is required, then K_a must be greater (1) if K_a is greater then dissociation equilibrium must have shifted to the right (1) dissociation must be endothermic (1) ecf possible			3	3		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		$2CH_3CH_2COOH + CaO \rightarrow (CH_3CH_2COO)_2Ca + H_2O$		1		1		1
		(ii)		moles of CaO = $\frac{1.20}{56.1}$ = 0.0214 (1) 0.0214 × 186.1 = 3.98 (1)		1 1		2	1	1
				Question 10 total	**2**	**8**	**4**	**14**	**6**	**2**

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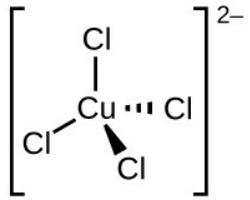
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$	1			1		
	(b)			d-orbitals are full in Cu^+ so electrons cannot be excited / cannot absorb light energy	1			1		
	(c)	(i)			1			1		
		(ii)		heating to complete dryness removes water ligands (1) d-orbital splitting is removed / d-orbitals are all of the same energy (1)	1	 1		2		1
	(d)	(i)		standard enthalpy change of formation of $CuCl_2$ is more negative than that of CuCl so $CuCl_2$ is more stable		1		1		
		(ii)		they are elements in their standard states	1			1		
		(iii)		chlorine is the only gas and gases have higher entropy than solids		1		1		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iv)		$\Delta H = -206 - [2 \times (-138)] = 70$ (1) $\Delta S = -33$ (1) ΔG needs to be negative for reaction to occur (1) $\Delta G = \Delta H - T\Delta S$ cannot be negative with ΔH positive and ΔS negative (1)		1 1	 1	 4	1 1 1	
		(v)		heating increases rate		1		1		1
	(e)			reducing agent must have more negative SEP than Cu^{2+}/Cu^{+} system (1) only H_3PO_2 is a suitable reducing agent (1)			1 1	2		
				Question 11 total	**5**	**6**	**4**	**15**	**3**	**2**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	*(a)*	(i)		$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$		1		1		
		(ii)		$-114 = (2 \times \Delta_f H^\theta) - (2 \times 91)$ (1) $\Delta_f H^\theta = 34$ (1)		1 1		2	1	
		(iii)	I	oxidation state of N goes from +4 to +5 and +2 (1) it is disproportionation as the N has been oxidised and reduced (1)	1	1		2		
			II	$n(NO_2) = \frac{1.85}{46} = 0.0402$ mol (1) energy released = $\frac{-117 \times 0.0402}{3} = 1.57$ kJ (1) temperature rise = $\frac{1.57 \times 1000}{120 \times 4.18} = 3.1\,°C$ (1) final temperature = 22.8 °C (1)	1	1 1 1		4	1 1 1	
			III	concentration of acid = $\frac{0.0268}{0.120} = 0.2234$ mol dm^{-3} (1) pH = –log 0.2234 = 0.65 (1)		2		2	2	
			IV	award (1) for either of following recycle NO into step 2 add oxygen to oxidise NO (to NO_2)			1	1		

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			changes under standard conditions so T = 298K (1) rearranged equation ⇨ $\Delta S = \frac{(\Delta H - \Delta G)}{T}$ (1) $\Delta S = \frac{[-137-(-88)]}{298 \times 1000}$ = –164 (1)		1 1	1	3	1 1	
	(c)	(i)		$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ ignore any state symbols	1			1		
		(ii)		sulfuric acid reacts fastest, followed by nitric acid and ethanoic acid is slowest (1) ethanoic acid is slowest as it only dissociates partially so concentration of H^+ ions is lower (1) sulfuric acid is fastest as each acid has two acidic protons / releases two H^+ ions so has a higher concentration of H^+ (1)		1 1	1 1	3		
		(iii)		award (1) for either of following reaction with sulfuric acid will give a precipitate rather than a solution reaction will be slower as barium carbonate will be coated in insoluble barium sulfate			1	1		1
				Question 12 total	**3**	**12**	**5**	**20**	**8**	**1**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	*(a)*			coordinate bond is a pair of shared electrons (1) both come from the same atom whereas in a covalent bond one comes from each atom (1)	2			2		
	(b)			chlorine isotopes are chlorine-35 and chlorine-37 (can be shown in calculations) (1) lightest molecular ion = 132, heaviest molecular ion = 138 (1) isotope ratio ^{35}Cl : ^{37}Cl is 3:1 (can be shown from calculations or expressed as percentages) (1) ratio is 1:27 (1) ecf possible from incorrect ratio	1 1	 1	 1	 4	 1	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		**Indicative content** 1. Hydrogen bonds are intermolecular forces 2. Occur when hydrogen is bonded to N, O, F 3. These are the most electronegative elements 4. The bond has a large dipole 5. The hydrogen nucleus is exposed / naked / low electron density 6. The forces are stronger than van der Waals / strongest intermolecular forces 7. Increases boiling temperature 8. Need more energy to break hydrogen bonds (than van der Waals) 9. Leads to solubility in water 10. Molecules can form hydrogen bonds with water molecules Many points can be credited from appropriate labelled diagram(s)	3	3		6		
				5-6 marks Includes at least eight relevant points, including all of points 7-10 *The candidate constructs a relevant, coherent and logically structured account including all 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** Includes at least six relevant points, including at least two of points 2, 3, 4 and either 7 or 9 *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** Includes at least four relevant points *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. 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.*						

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)	I	density increases (slightly) as temperature increases initially then decreases more significantly (1) above 3-4°C (1)		 1	1	2		
			II	volume of water = 1.0018 dm^3 (1) moles in 1 kg = $\frac{1000}{18.02}$ = 55.49 (1) concentration = 55.59 (1) **must** be to 4 sig figs		1 1	1	3	2	
				Question 13 total	**7**	**7**	**3**	**17**	**3**	**0**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
14	*(a)*			to ensure sample is homogeneous (1) to increase surface area so that reaction rate is increased / that acid can react with all sample (1)			2	2		2
	(b)			calcium sulfate would be formed which is only sparingly soluble (and can prevent complete reaction)			1	1		1
	(c)	(i)		Anne's method (1) must attempt reason to gain mark measurements more precise / to more significant figures / carbon dioxide may dissolve in the water (1)			2	2		2

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		calculation must be for the method they have chosen in part (i) - otherwise award (3) max Anne's method n(NaOH) = $\frac{20.65 \times 1.00}{1000}$ = 2.065 × 10^{-2} mol (1) original n(HCl) = $\frac{25 \times 2}{1000}$ = 0.0500 moles of HCl that reacted with carbonate = 0.0500 – 0.02065 = 0.02935 (1) moles of carbonate = $\frac{0.02935}{2}$ = 0.0147 percentage = $\frac{0.0147 \times 60}{1.510} \times 100$ = 58.4% (1) answer given to 3 sig figs [as A_r values have 3 sig figs] (1) Jack's method award (1) for appropriate units throughout ⇨ 289K 96 × 10^{-6} m^3 1.01 × 10^5 Pa moles of gas = $\frac{1.01 \times 10^5 \times 96 \times 10^{-6}}{8.31 \times 289}$ mass of carbonate = 4.0 × 10^{-3} × 60.0 = 0.24 (1) percentage = $\frac{0.24}{0.41} \times 100 = 59\%$ (1) answer to 2 sig figs (1)		2	2	4	3	

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		based on Anne's method percentage by mass due to Mg = 100 – 3.00 – 37.66 – 58.3 = 1.04% (1) percentage dolomite by mass = $\frac{1.04 \times 184.4}{24.3}$ = 7.89% (1) ecf possible based on Jack's method percentage by mass due to Mg = 100 – 3.00 – 37.66 – 59 = 0.34% (1) percentage dolomite by mass = $\frac{0.34 \times 184.4}{24.3}$ = 2.6% (1) ecf possible		2		2	1	
	(d)	(i)		$M_r(CaCO_3)$ = 100.1, M_r of CaO = 56.1 (1) *allow M_r values as round numbers* atom economy = 56% (1)		2		2	1	
		(ii)		produces carbon dioxide (1) which is a greenhouse gas / contributes to climate change (1) requires a high temp so considerable energy needed (1) this generates carbon dioxide as fossil fuels are burnt (1)	1	1		2		
		(iii)		any value above 1000K (1) must attempt reason to gain mark stability of carbonates increases down Group 2 (1)	1	1		2		
				Question 14 total	**2**	**8**	**7**	**17**	**5**	**5**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
15	*(a)*			<table><tr><th>Solution</th><th>Relative formula mass (M_r)</th></tr><tr><td>**A**</td><td>331(.0)</td></tr><tr><td>**B**</td><td>150(.0)</td></tr><tr><td>**C**</td><td>56.11</td></tr><tr><td>**D**</td><td>159.5</td></tr></table> award (2) for all 4 correct award (1) for any 2 correct		2		2	1	
	(b)			**Indicative content** Identities **A** ⇨ lead(II) nitrate / $Pb(NO_3)_2$ **B** ⇨ sodium iodide / NaI **C** ⇨ potassium hydroxide / KOH **D** ⇨ copper(II) sulfate / $CuSO_4$ 1. lilac flame test ⇨ potassium 2. yellow flame test ⇨ sodium 3. pale blue solution contains Cu^{2+} 4. white solid in a brown solution caused by mixing Cu^{2+} with I^- [or solid is CuI and solution contains I_2] 5. bright yellow precipitate caused by mixing Pb^{2+} with I^- [or solid is PbI_2] 6. pale blue precipitate caused by mixing Cu^{2+} with OH^- [or solid is $Cu(OH)_2$] 7. white precipitate that dissolves in excess shows **A** contains amphoteric metal and **C** contains OH^- 8. **A** is a soluble lead salt so must be nitrate (or ethanoate) 9. **A** has M_r 331 which is lead(II) nitrate 10. **B** has metal ion(s) of mass 150 – 127 = 23 so must be Na^+ 11. **C** has metal ion(s) of mass 56.11 – 17.01 = 39.1 so must be K^+ 12. **D** has anion(s) of mass 159.5 – 63.5 = 96 which must be SO_4^{2-}		1	5	6		6

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Question				Marking details
				5-6 marks At least 6 ions correctly identified with at least 6 indicative points, including the use of at least one M_r to identify a compound *The candidate constructs a relevant, coherent and logically structured account including all 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** At least 4 ions correctly identified with at least 5 indicative points *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** At least 2 ions correctly identified with at least 2 indicative points *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. 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.*

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			find the convergence limit of the Lyman series (1) apply $E = hf$ using the frequency of the convergence limit (1)	2			2		
				Question 15 total	**2**	**3**	**5**	**10**	**1**	**6**

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COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	8	6	1	15	6	1
9	5	5	2	12	2	0
10	2	8	4	14	6	2
11	5	6	4	15	3	2
12	3	12	5	20	8	1
13	7	7	3	17	3	0
14	2	8	7	17	5	5
15	2	3	5	10	1	6
Totals	34	55	31	120	34	17

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