GCE A LEVEL MARKING SCHEME

SUMMER 2022

A LEVEL
CHEMISTRY – COMPONENT 1
A410U10-1

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

COMPONENT 1 – PHYSICAL AND INORGANIC CHEMISTRY

SUMMER 2022 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.

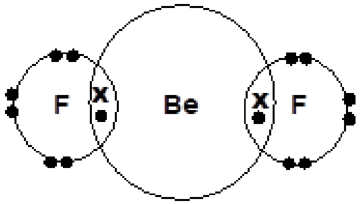
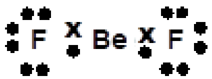
Marking abbreviations

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				$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$	1			1		
2	(a)			$\overset{\delta+}{C}-\overset{\delta-}{Cl}$ $\overset{\delta+}{H}-\overset{\delta-}{Cl}$ $\overset{\delta-}{O}-\overset{\delta+}{Cl}$ all three needed		1		1		
	(b)			<u>difference in electronegativity</u> between Al and Cl is not big enough for compound to be ionic / is less than 2.0		1		1		
3				award (1) for either of following  	1			1		
4				outer electron in N is unpaired but in O it is paired (1) accept statement or diagram paired electrons repel each other more strongly and so require less energy to lose (1)	2			2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	(a)			$[H^+] = \frac{K_W}{[OH^-]} = \frac{1.00 \times 10^{-14}}{0.200}$ = 5.00 × 10^{-14} (1) pH = –log[H^+] = 13.3 (1)		2		2	2	
	(b)			accept any value in the range 7.5-11 as it is a salt of weak acid and strong base (the ethanoate sets up an equilibrium $CH_3COO^- + H^+ \rightleftharpoons CH_3COOH$) value **and** reason needed		1		1		
6				energy per atom = 1.226 × 10^{-18} J (1) frequency = $\frac{E}{h}$ = 1.85 × 10^{15} Hz (1)		2		2	2	
7				+2 due to the inert pair effect (which increases down Group 4)	1			1		
8	(a)			(first) electron affinity of <u>chlorine</u>		1		1		
	(b)			enthalpy change = –(–411) + 107 + 122 + 496 + (–349) (1) 787 kJ mol^{-1} (1)		2		2	1	
				Section A total	**5**	**10**	**0**	**15**	**5**	**0**

Section B

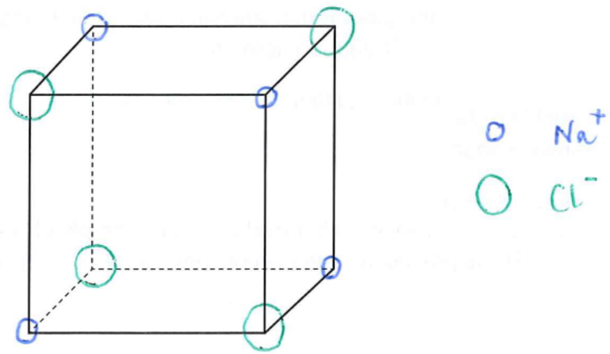
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	(a)	(i)		mass of an atom of an isotope relative to $\frac{1}{12}$ th of the mass of a carbon-12 atom	1			1		
		(ii)		$\frac{(135.9 \times 0.19) + (137.9 \times 0.25) + (139.9 \times 88.45) + (141.9 \times 11.11)}{100}$ (1) 140.1 (1) award further (1) if answer given to 4 sig figs ecf possible		3		3	2	
	(b)	(i)		Decay of ^{134}Ce La 134 (1) Decay of ^{143}Ce Pr 143 (1) if incorrect award (1) for two correct symbols or two correct masses		2		2		
		(ii)		no change in mass (during β decay or electron capture) (1) so isotope produced and initial isotope would produce one peak in mass spectrum / cannot distinguish between parent and daughter isotope in mass spectrum (1)			2	2		
		(iii)		25% of ^{144}Ce remains ⇨ 2 half-lives have passed ⇨ 560 days (1) 560 days ⇨ 4 half-lives for ^{139}Ce have passed ⇨ 6.25% remaining (1) percentage $^{139}Ce = \frac{6.25}{(25 + 6.25)} \times 100 = 20\%$ (1)			3	3	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		**Indicative content** 1. Moles of $Ce(SO_4)_2$ required ⇨ 0.0500 mol 2. Mass of $Ce(SO_4)_2$ required ⇨ 16.6g 3. Measure mass of $Ce(SO_4)_2$ into a beaker and add a small amount of deionised water 4. Dissolve solid 5. Transfer to 250 cm^3 volumetric flask using a funnel 6. Wash glass rod / funnel / beaker with deionised water and transfer into volumetric flask 7. Add deionised water until meniscus is on the line 8. Stopper and mix thoroughly by inverting several times	4	2		6	1	6
				5-6 marks Correct mass of $Ce(SO_4)_2$; five steps from the method included and in the correct order. *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** Correct number of moles of $Ce(SO_4)_2$; four steps from the method included. *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** Three steps from the method included; reference to two pieces of apparatus. *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.*						

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		moles $Ce^{4+} = \frac{22.45 \times 0.200}{1000} = 4.49 \times 10^{-3}$ (1) moles $Fe^{2+} = 4.49 \times 10^{-3}$ (1) mass $FeCO_3 = 4.49 \times 10^{-3} \times 115.8 = 0.520$ g (1)		3		3	1	3
		(iii)		titration would measure all Fe present – not just that in $FeCO_3$ (1) measure volume of gas produced upon addition of acid (1) any suitable method e.g. gas syringe, displacement of water (1) accept alternative measure mass of gas produced upon addition of acid (1) carry out reaction in a flask on a weighing balance (1)			3	3		3
	(d)			H_2O_2 (1) award (1) for either of following this has a more positive standard electrode potential than Ce^{4+}/Ce^{3+} so is able to oxidise Ce^{3+} EMF for the reaction is positive EMF = +1.78 – (+1.61) = +0.17V so reaction is feasible		1	1	2		
				Question 9 total	**5**	**11**	**9**	**25**	**6**	**12**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	(a)			6.31×10^{-4}		1		1	1	
	(b)	(i)		for reaction to be feasible entropy overall must increase / Gibbs free energy must be negative (1) award (1) for either of following • in this reaction a gas is produced which has a much greater entropy than reactants and this overcomes the effect of the endothermic energy change • ΔS is positive as a gas is produced which has a much greater entropy than reactants so $-T\Delta S$ is greater than ΔH making ΔG negative		1	1	2		
		(ii)		temperature and volume in appropriate units 289 K and 72.2×10^{-6} m^3 (1) n(CO_2) = $\frac{pV}{RT}$ = 3.035×10^{-3} mol (1) concentration of citric acid = $\frac{\frac{3.035 \times 10^{-3}}{3}}{0.050}$ = 2.02×10^{-2} mol dm^{-3} (1)		3		3	2	
		(iii)	I	to ensure the temperature has become constant / to ensure thermal equilibrium with surroundings	1			1		1
			II	to allow for adjustment for heat gained from surroundings / to allow for heat transfer between cup and surroundings do not accept – to allow for heat loss to surroundings	1			1		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
			III	moles citric acid = 0.025 (1) moles $NaHCO_3$ = 0.0274 (1) each citric acid reacts with 3 $NaHCO_3$ so 0.025 mol of citric acid can react with 0.075 mol $NaHCO_3$ ⇨ citric acid is in excess (1)		2	1	3		3
			IV	$\frac{2 \times 0.05}{2.3} \times 100$ = 4.3%		1		1		1
			V	energy = $m \times c \times \Delta T$ = 25.0 × 4.18 × –10.1 = –1055 J (1) moles reacting = 0.0200 (1) enthalpy change = 52.8 kJ mol^{-1} (1)		3		3	2	3
	(c)	(i)		$[H^+]$ = 1.288 × 10^{-3} mol dm^{-3} (1) acid concentration = $\frac{[H^+]^2}{K_a}$ = 0.0118 mol dm^{-3} (1)		2		2	2	
		(ii)	I	solution that keeps pH (relatively) constant when small amounts of acid or base are added	1			1		
			II	concentration of lactic acid = 2 × concentration of sodium lactate $[H^+] = K_a \times \frac{[\text{acid}]}{[\text{salt}]} = K_a \times 2$ (1) $[H^+]$ = 2.80 × 10^{-4} (1) pH = 3.55 (1)		2	1	3	2	
				Question 10 total	**3**	**15**	**3**	**21**	**9**	**9**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	(a)			oxygen atoms in water = $\frac{108}{1.01}$ × ½ = 53.465 mol (1) percentage oxygen in water = $\frac{53.465}{\frac{857}{16}}$ × 100 = 99.8% (1)		2		2	1	
	(b)	(i)		award (2) for **all** four correct award (1) for any **two** correct Na golden/yellow Mg no colour Ca brick-red K lilac	2			2		2
		(ii)		colours can mask or hide each other			1	1		1
	(c)			 face centred cubic arrangement (1) labelling (1) do **not** accept reference to sodium/chlorine atoms	2			2		

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(d)			2 molecules H_2O represents 16.44% of mass of hexahydrate 36.04 = 16.44% of M_r of hexahydrate (1) M_r of hexahydrate = $36.04 \times \frac{100}{16.44}$ = 219.22 (1) award (1) for identity of salt $CaCl_2$ $CaCl_2.6H_2O$			3	3	1	
	(e)	(i)		$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$	1			1		
		(ii)		concentration = $\frac{0.0673}{(79.9 \times 2)}$ = 4.21×10^{-4} mol dm^{-3}		1		1		
	(f)			decrease in pH means a higher concentration of H^+ ions (1) increasing concentration of H^+ shifts equilibria to left (1) this produces less CO_3^{2-} (so marine creatures cannot form shells) (1)		3		3		
				Question 11 total	**5**	**6**	**4**	**15**	**2**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	(a)			iodide / I^- (1) **must** suggest reason for this mark because (anion is monatomic and) it produces smell of rotten eggs with conc H_2SO_4 (1)	1		1	2		2
	(b)	(i)		ligands split *d*-orbitals into two higher and three lower energy (1) electrons absorb specific amount of light energy to go from lower to higher energy level (1) colours seen are the remaining colours that are not absorbed OR colours reflected (1) credit possible from appropriately labelled diagrams	3			3		
		(ii)		M is not amphoteric	1			1		1
	(c)			ammonia / NH_3 (1) gas released which turns red litmus blue is ammonia (1)			2	2		2
	(d)			6	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(e)			mass of six NH_3 ligands = 102.18 mass of three en ligands = 180.24 (1) difference of 78.06 is 18.82% of original M_r ⇨ original M_r = 414.8 (1) M_r due to metal is 58.6 ⇨ M is nickel / Ni (1) accept cobalt / Co if rounding gives this M_r			3	3	2	
	(f)			$[Ni(NH_3)_6]^{2+}$ ecf possible but 2+ charge **must** be correct			1	1		
	(g)	(i)		$M(OH)_2 \rightarrow MO + H_2O$	1			1		1
		(ii)		hydroxides become more thermally stable down the group	1			1		1
		(iii)		$T = \frac{\Delta H}{\Delta S} = \frac{117000}{175}$ (1) 669 K (1)		2		2	1	
				Question 12 total	**8**	**2**	**7**	**17**	**3**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	(a)			**Indicative content** PATTERNS: 1. Boiling temperature drops from ammonia to phosphane 2. Boiling temperature increases from phosphane to stibane 3. Solubility of ammonia is much higher than others, which have a very low solubility EXPLANATION: 4. Ammonia is able to form hydrogen bonds between molecules 5. Other three are not able to form hydrogen bonds / ONLY have van der Waals forces between molecules 6. Hydrogen bonds are stronger than van der Waals forces 7. So more energy is needed to overcome forces between molecules of ammonia than others 8. As we go down the group the molecules contain more electrons 9. So there are stronger van der Waals forces between molecules 10. Giving a higher boiling temperature 11. Ammonia can form hydrogen bonds with water molecules so it is soluble; others cannot so are insoluble 12. Ammonia can form hydrogen bonds because it has hydrogen bonded to a very electronegative atom. 13. This creates a large dipole due to an exposed hydrogen nucleus.	4	2		6		

Question				Marking details
				5-6 marks Patterns identified with good attempt at explanation of differences in boiling temperature and solubility. *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** Patterns identified with some attempt at explanation with reference to hydrogen bonding and van der Waals forces. *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 pattern identified with some attempt at explanation. *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.*

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			phosphorus has three bond pairs and one lone pair (1) electron pairs repel to be as far from each other as possible / lone pairs repel more than bond pairs (1) shape is pyramidal (1)	 1 1	1		3		
	(c)	(i)		reaction ratio is 3:2 so will produce 1½ times initial pressure (1) 63000 Pa (1)		2		2	2	
		(ii)		tangent at t = 0 (1) gradient of tangent = 340 (Pa hr^{-1}) (1) accept any value in the range 310-370		2		2	2	2
		(iii)		pressure when half the SbH_3 had decomposed $\frac{(42000 + 63000)}{2}$ = 52500 Pa (1) tangent at 52500 (1) rate of change of pressure = 170 (Pa hr^{-1}) (1) accept any value in the range 155-185 initial rate of change of pressure [from part (ii)] = 340 (Pa hr^{-1}) ecf possible when concentration of SbH_3 is halved rate is halved OR rate is proportional to concentration of SbH_3 so first order reaction (1) *can refer to rate of decomposition or rate of change of pressure here*		1	2 1	4	3	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				alternative method pressure when half the SbH_3 had reacted $\frac{(42000 + 63000)}{2}$ = 52500 Pa (1) half of remaining SbH_3 would have reacted when pressure is $\frac{(52500 + 63000)}{2}$ = 57750 Pa (1) 43 hr to reach 52500 and another 43 hr to reach 57750 / 86 hr for pressure to halve twice (1) constant half-life so first order reaction (1)						
	(d)	(i)		catalyst in a different physical state to reactants	1			1		
		(ii)		no effect (1) catalyst affects the rate of both forward and reverse reaction equally (1)	2			2		
		(iii)		award (1) for appropriate units throughout T = 773 K $E_{a(Fe)}$ = 101400 J mol^{-1} $E_{a(Ru)}$ = 64000 J mol^{-1} k = $Ae^{-E_a/RT}$ **f** = $Ae^{-E_{a(Ru)}/RT} \div Ae^{-E_{a(Fe)}/RT} = e^{-E_{a(Ru)}/RT} \div e^{-E_{a(Fe)}/RT}$ (1) **f** = 338 (1)		1	2	3	3	

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(e)			initial concentrations - both needed for (1) 2.00×10^{-3} PH_2D 9.80×10^{-4} H_2O equilibrium concentrations - both needed for (1) 7.20×10^{-4} PH_3 7.20×10^{-4} HDO equilibrium concentrations - both needed for (1) 1.28×10^{-3} PH_2D 2.60×10^{-4} H_2O K_c = 1.56 (1) ecf possible		1 1	 1 1	4	2	
				Question 13 total	**9**	**11**	**7**	**27**	**12**	**5**

COMPONENT 1: PHYSICAL AND INORGANIC CHEMISTRY

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	5	10	0	15	5	0
9	5	11	9	25	6	12
10	3	15	3	21	9	9
11	5	6	4	15	2	3
12	8	2	7	17	3	7
13	9	11	7	27	12	5
Totals	35	55	30	120	37	36