GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
CHEMISTRY – COMPONENT 1
A410U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2020 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

AUTUMN 2020 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.

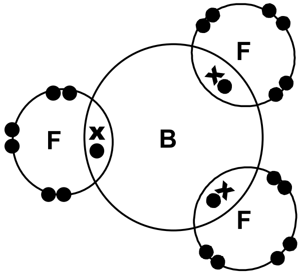
Marking abbreviations

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)*					1		1		
	(b)			(three) electron / bond <u>pairs</u> repel each other to be as far away from each other as possible / arrange themselves to minimise repulsion		1		1		
2				$NaHSO_4$ SO_2 H_2S S award (2) for **all four** correct award (1) for **any two** correct	2			2		2
3	*(a)*			beta / β / β^- do not accept β^+	1			1		
	(b)			award (2) for 0.242 if answer incorrect award (1) for indication of three half-lives		2		2	1	

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4	*(a)*			CuI	1			1		1
	(b)	(i)		value is too far from other values / is not concordant		1		1	1	1
		(ii)		2.385×10^{-3} accept rounding to 2.39×10^{-3} or 2.4×10^{-3}		1		1	1	1
5	*(a)*			award (1) for either of following • ammonia has hydrogen bonding between molecules but the others do not • ammonia has hydrogen bonding between molecules but the others only have van der Waals forces hydrogen bonding is stronger than van der Waals forces (1)	1	1		2		
	(b)			stronger van der Waals forces between molecules of arsine as arsine has more electrons		1		1		
6				SEP for chlorine is more positive than that for Fe^{3+}/Fe^{2+} so chlorine can oxidise Fe^{2+} to Fe^{3+} and form $FeCl_3$ (1) SEP for iodine is less positive than that for Fe^{3+}/Fe^{2+} so iodine cannot oxidise Fe^{2+} further and so forms FeI_2 (1) do not accept if values calculated but equations written as $Fe + X_2$		2		2		
				Section A total	**5**	**10**	**0**	**15**	**3**	**5**

Section B

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*			as the number of chlorine atoms increases the acid becomes stronger		1		1		
	(b)			$[H^+]^2 = 1.43 \times 10^{-3} \times 0.2 = 2.86 \times 10^{-4}$ (1) pH = – log $[H^+]$ = 1.8 (1) award (1) for 3.54		2		2	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)	(i)		moles = $\frac{0.68}{136.09}$ = 5.00×10^{-3} (1) volume of water = 2.06 (1) volume of water too small to filter easily (1)		2	1	3	2	1
		(ii)		use graduated pipette rather than measuring cylinder as it is more precise (1) ethanoic acid is a weak acid so pH changes gradually in the range 3.1-4.4 (1) accept reference to equivalence point above 7; use an indicator that changes in the basic region / use phenolphthalein (1) volume of sodium hydroxide used will be very small (so large percentage error) (1); use acid and alkali with similar concentrations (1) if full credit not awarded allow (1) for comment on safety / risk and how this can be reduced / avoided e.g. high concentration of NaOH is hazardous so use lower concentration			5	5		5
				Question 7 total	**0**	**5**	**6**	**11**	**4**	**6**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*			(for a metal to melt) forces between metal ions and (sea of) delocalised electrons must be overcome (1)	1			2		
				award (1) for either of following • greater positive charge on magnesium ions therefore stronger forces present • more delocalised electrons therefore stronger forces present		1				
	(b)			magnesium is the better conductor as it has more delocalised electrons / more outer shell electrons (that can move and carry charge) do not accept magnesium has two outer electrons without comparison with sodium			1	1		
	(c)	(i)		$Mg^{2+}(g) \rightarrow Mg^{3+}(g) + e^-$		1		1		
		(ii)		tenth electron removed from innermost shell in sodium whilst it is removed from the second shell in magnesium (1) no shielding in sodium whilst there is some shielding by inner shell for magnesium (1)	1	1		2		
		(iii)		estimated $\log_{10}$(ionisation energy) between 3.4 and 3.7 (1) accept answers in the range 2512 to 5012 (1) allow ecf if estimated $\log_{10}$(ionisation energy) is between 2.8 and 3.8		1	1	2	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		ΔH = 117 kJ mol^{-1} (1) ΔS = 175 J K^{-1} mol^{-1} (1) T = $\frac{117}{0.175}$ (1) minimum temperature = 396 (1)		4		4	3	
		(ii)		any value above 400°C because metal carbonates become more stable down Group 2 ecf possible from part (d)(i)	1					1
				Question 8 total	**3**	**8**	**2**	**13**	**5**	**1**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*	(i)		ability of an atom to attract a pair of electrons in a covalent bond	1			1		
		(ii)		(polar) covalent bond as the difference in electronegativity is too small for ionic / difference in electronegativity between 0.5 and 2.0	1			1		
	(b)	(i)		20.2 (2) if answer incorrect award (1) for $\frac{21.97}{108.81}$		2		2		
		(ii)		choice of CH_3Cl or CH_3Br with more advantages stated for chosen compound (1) award (1) each for **any three** of the following points expressed as two advantages of chosen compound and one disadvantage of chosen compound (or advantage for other compound) • CH_3Cl better as it has a higher atom economy / less waste • CH_3Cl better as easier to remove LiCl than LiBr as it is insoluble • CH_3Cl better as it costs less per mol of reactant • CH_3Br better as it has a higher boiling temperature so easier to use as a liquid • CH_3Br better because CH_3Cl can deplete ozone layer OR is a greenhouse gas award 2 max for reasons if reference to CH_3Br being cheaper			4	4		
	(c)			a substance that removes / accepts H^+ in a non-reversible reaction	1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(d)	(i)		n(CH_4) = $\frac{391.8}{24500}$ = 0.01599 (1) dissolved in 10 cm^3 of solvent ⇨ 1.599 or 1.60 (2) accept answer to 4 sig figs (or 3 sig figs due to A_r values) award (1) for correct answer to different number of sig figs		3		3	2	
		(ii)		[H^+] = $10^{-12.8}$ = 1.585 × 10^{-13} (1) [OH^-] = $\frac{1.0 \times 10^{-14}}{1.585 \times 10^{-13}}$ = 0.06310 (1) [CH_3Li] = 0.06310 × $\frac{0.250}{0.01}$ = 1.58 (1) accept 1.6 / 1.64		3		3	3	
		(iii)		gas volume is better (1) MUST ATTEMPT REASON TO GAIN THIS MARK more precise / more significant figures in measurements (1)			2	2		
		(iv)		$\Delta T = -\frac{\Delta H \times n}{m \times c}$ (1) $\Delta T = -\frac{-198\,000 \times 0.010}{250.0 \times 4.18}$ (1) ΔT = 1.9°C (1)	1	2		3	3	
				Question 9 total	**4**	**10**	**6**	**20**	**8**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*			does not form an ion with partially filled d-orbitals	1			1		
	(b)			pink	1			1		1
	(c)	(i)		copper(II) hydroxide / $Cu(OH)_2$	1			1		1
		(ii)		**Indicative content** 1. **A** is $[Cu(H_2O)_2(NH_3)_4]^{2+}$ 2. **B** is $[Cu(H_2O)_6]^{2+}$ 3. **C** is $[CuCl_4]^{2-}$ 4. $[Cu(H_2O)_2(NH_3)_4]^{2+} + 4H_2O \rightleftharpoons [Cu(H_2O)_6]^{2+} + 4NH_3$ 5. dilute hydrochloric acid includes water - this pushes equilibrium to right 6. hydrochloric acid protonates ammonia / turns ammonia into ammonium - reduced ammonia concentration shifts equilibrium to right 7. $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CuCl_4]^{2-} + 6H_2O$ 8. concentrated hydrochloric acid provides chloride ions 9. concentrated hydrochloric acid provides much more chloride than water - this pushes equilibrium to right 10. addition of water shifts equlibrium to left as it decreases concentration of chloride ions / increases concentration of water	3	1	2	6		6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks All three species identified and six relevant points included; Le Chatelier's principle used correctly in explaining some processes; one fully correct equation *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** Two species identified and five relevant points included; Le Chatelier's principle used correctly in explaining one process *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 species identified and four relevant points included *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.*						
	(d)			e.g. variable oxidation states (1) copper can form +1 and +2 / zinc only forms +2 (1)	2			2		
				Question 10 total	**8**	**1**	**2**	**11**	**0**	**8**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*			advantage can use renewable fuels / can be carbon-neutral / higher efficiency in obtaining useful energy (1) disadvantage hydrogen is explosive so difficult to store and transport / lower energy density / need expensive catalysts (1) reference to cost alone is not sufficient	2			2		
	(b)	(i)		$n = \frac{pV}{RT}$ (1) $n(H_2) = \frac{1.14 \times 10^5 \times 2856 \times 10^{-6}}{8.31 \times 320} = 0.1224$ (1) $n(NaOH) = 2 \times 0.1224 = 0.245$ (1) $[NaOH] = \frac{0.245}{0.250} = 0.979$ (1)		4		4	4	
		(ii)		$V_1 = \frac{p2 \times V2 \times T1}{T2 \times p1}$(1) $V_1 = 570$ (1)		2		2	2	
		(iii)		student is incorrect (must attempt reason to gain this mark) (1) must use a weak base or weak acid for a buffer (1) need reversible reaction involving gain / loss of H^+ ions (1)			3	3		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			**Indicative content** 1. energy (levels) in an atom are quantised 2. energy levels become closer together in energy as you move to higher quantum levels / shells / further from nucleus 3. energy is emitted / lines are produced when electron drops from higher level to lower level 4. each series of lines corresponds to dropping to a particular energy level 5. link name of at least one set of lines to location in spectrum (Lyman ⇨ uv ⇨ drop to n=1; Balmer ⇨ light / visible ⇨ drop to n=2; Paschen ⇨ IR ⇨ drop to n=3) 6. convergence limit of Lyman corresponds to ionisation energy 7. this is 91 nm line 8. use $E = hf$ or $E = \frac{hc}{\lambda}$ to convert frequency / wavelength to energy 9. correct use of Avogadro number in calculation 10. ionisation energy is 1316 kJ mol^{-1}	4	2		6	3	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Six relevant points included; correct ionisation energy calculated *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** Four relevant points included; knowledge of quantisation; line needed to calculate the ionisation energy identified *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 relevant points included *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
	(d)	(i)		–1286 = 6[C—H] + 2[O—H] + 3[O=O] + 2[C—O] – 4[C=O] – 8[O—H] (1) –1286 = 2[C—O] – 2018 (1) [C—O] = 366 (1)		3		3	2	
		(ii)		bond energies given are averages / not the same in every molecule	1			1		
		(iii)		it is value for combustion of 1 methanol molecule (1) methanol / water is not in standard state (1) not standard conditions / temperature is not 25°C (1)			3	3		
				Question 11 total	**7**	**11**	**6**	**24**	**11**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
12	*(a)*	(i)		catalyst in a different (physical) state from reactants	1			1		
		(ii)		award (1) for any appropriate answer e.g. Fe in the Haber process Ni / Pd for hydrogenation of alkenes V_2O_5 in the contact process	1			1		
	(b)	(i)	I	mol dm^{-3} s^{-1}		1		1	1	
			II	$k = Ae^{\frac{-Ea}{RT}}$ (1) unit of E_a changed from kJ to J (1) $k = 1.71 \times 10^3$ (mol dm^{-3} s^{-1}) (1) palladium catalyst is more effective as it has a higher rate (constant) at 600 K (1) if no calculation then accept answer in terms of E_a for this marking point	1	1	2	4	4	
		(ii)		$CO + O_2 \rightarrow CO_2 + O$ (1) $CO + O \rightarrow CO_2$ (1) first step is rate determining step (1)			3	3		

Question				**Marking details**	**Marks available**					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(c)	(i)		award (1) for any of following • substance that is (easily) oxidised in a chemical reaction (and hence reduces another species) • substance that loses electrons easily (giving them to another species) • substance that can provide electrons (to another species)	1			1		
		(ii)		carbon is more stable in oxidation state +4 whilst lead is more stable in oxidation state +2 (1) due to the inert pair effect increasing down the group (1)	2			2		
				Question 12 total	**6**	**2**	**5**	**13**	**5**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
13	*(a)*			**A** carbonate / CO_3^{2-} **B** oxide / hydroxide / O^{2-} / OH^- **C** **UNKNOWN** **D** sulfate / SO_4^{2-} **E** bromide / Br^- **F** iodide / I^- **G** chloride / Cl^- award (1) for identification of **C** as the unknown ion award (1) for each two other ions correctly identified penalise (1) mark only if **E**, **F** or **G** given as halogen rather than halide			4	4		4
	(b)			award (1) each for **any two** of following • sodium carbonate <u>and</u> sodium hydroxide / all sodium salts are soluble • sodium carbonate <u>and</u> sodium sulfate would give a precipitate with barium chloride • sodium carbonate <u>and</u> sodium hydroxide would give a precipitate with silver nitrate award (1) for any of following • add (nitric) acid to all samples to test for carbonate • add (nitric) acid to all samples before adding silver nitrate or barium chloride • temperature rise when acid is added to oxide / hydroxide			3	3		3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(c)			1 dm^3 of solution has a mass of 900 g (1) mass of ammonia in 900 g of solution is 279 g (1) conc^n = $\frac{279}{17.03}$ = 16.4 (1)		3		3	2	
	(d)			sodium <u>and</u> the mixture would give a yellow / orange flame (1) magnesium would give no flame colour (1) not appropriate as cannot distinguish between sodium only and the mixture (1)	2		1	3		3
				Question 13 total	**2**	**3**	**8**	**13**	**2**	**10**

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	3	5
7	0	5	6	11	4	6
8	3	8	2	13	5	1
9	4	10	6	20	8	0
10	8	1	2	11	0	8
11	7	11	6	24	11	0
12	6	2	5	13	5	0
13	2	3	8	13	2	10
Totals	35	60	35	120	38	30