

A2 UNIT 3: PHYSICAL AND INORGANIC CHEMISTRY**MARK SCHEME****GENERAL INSTRUCTIONS**Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark, apart from questions where a banded 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.

A2 UNIT 3: PHYSICAL AND INORGANIC CHEMISTRY

MARK SCHEME

Section A

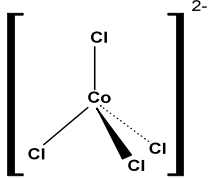
Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
1.			CH ₃ COOH and NH ₄ ⁺ identified – both required		1		1		
2.			potassium fluoride and rubidium fluoride – both required accept correct formulae do not accept if lithium fluoride included do not accept 'potassium' and 'rubidium'		1		1		
3.	(a)		3Cl ₂ + 6NaOH → 5NaCl + (1)NaClO ₃ + 3H ₂ O		1		1		
	(b)		<u>chlorine</u> oxidation state at <u>start</u> is <u>0</u> and at <u>end</u> is <u>-1 and +5</u> so it has been both oxidised and reduced		1		1		
4.			HCl at 1 mol dm ⁻³ or H ₂ SO ₄ at 0.5 mol dm ⁻³	1			1		1
5.			<i>lowest</i> Se(s) Br ₂ (l) Kr(g) <i>highest</i>		1		1		
6.			Cr ₂ O ₇ ²⁻ + 14H ⁺ + 6Fe ²⁺ → 2Cr ³⁺ + 7H ₂ O + 6Fe ³⁺		1		1		
7.			silicon possess available <i>d</i> -orbitals whilst there are none in the outer shell of carbon (therefore oxygen cannot bond)	1			1		
8.			oxygen 20.7% (1) formula CrO ₂ Cl ₂ (1)		2		2	1	
Section A total				2	8	0	10	1	1

Section B

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
9.	(a)	(i)	<u>outer</u> shell of electrons is not full / has fewer than 8 electrons	1			1		
		(ii)	NH ₃ .BCl ₃ (1) coordinate bond forms between lone pair on N and electron deficient BCl ₃ (1)	1 1			2		
	(b)	(i)	any two for (1) each up to max 2 <ul style="list-style-type: none"> • delocalised electrons in graphite and none in BN (1) • all atoms the same in graphite, alternating in BN (1) • atoms in planes lie above each other (in register) for BN and out of register for graphite (1) 	2			2		
		(ii)	I to ensure all the water molecules have been removed	1			1		1
			II moles water = $0.053 / 18.02 = 2.94 \times 10^{-3}$ (1) moles carbon = $3.592 / 12 = 0.299$ (1) ratio C: H ₂ O = 102: 1 [or 1: 9.82×10^{-3}] (1)			3	3	3	

GCE AS and A LEVEL CHEMISTRY SPECIMEN ASSESSMENT MATERIALS 130

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
9.	(c)	(i)	$K_p = \frac{P_{PCl_3} P_{Cl_2}}{P_{PCl_5}}$ <p>at equilibrium $P_{PCl_3} = 6.0 \times 10^3$ Pa and $P_{PCl_5} = 6.4 \times 10^3$ Pa (1)</p> $K_p = 5625$ (1) <p>error carried forward (ecf) possible award (3) for correct answer only (cao)</p> <p>Pa (1)</p>	1	1	1	4	1	
		(ii)	<p>increase in K_p indicates an increase in products when temperature is increased (1)</p> <p>endothermic [need reason for mark] (1)</p>			2	2		
		(iii)	<p>phosphorus can expand its octet but nitrogen cannot / phosphorus has <i>d</i>-orbitals in its valence shell nitrogen does not (1)</p> <p>this allows phosphorus to have more than 10 electrons in outer shell and form PCl_5 (1)</p>	2			2		
Question 9 total				9	5	3	17	6	1

Question		Marking details		Marks Available							
				AO1	AO2	AO3	Total	Maths	Prac		
10.	(a)			Cu – all boxes doubly filled apart from one in last (1) Cu ²⁺ – all boxes doubly filled apart from empty 4s and one in one <i>d</i> -orbital (1)	1				2		
	(b)			<p>Indicative content</p> <ul style="list-style-type: none"> [CoCl₄]²⁻ is complex formed  <ul style="list-style-type: none"> colour of complex is blue <i>d</i>-orbitals split by ligands electrons absorb light to move from lower to higher level colour seen is colour not absorbed <p>points 3 and 4 can be obtained from a labelled diagram</p>	6				6		

GCE AS and A LEVEL CHEMISTRY SPECIMEN ASSESSMENT MATERIALS 132

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
10.	(b)		<p>5-6 marks Each point included; no reference to emission of blue light <i>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 are used accurately throughout.</i></p> <p>3-4 marks Colour and formula of species; reference to splitting of <i>d</i>-orbitals by ligands; absorption of energy corresponding to difference between levels <i>The candidate constructs a coherent account including most of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.</i></p> <p>1-2 marks Colour or formula of species; splitting of <i>d</i>-orbitals; electrons move to another energy level <i>The candidate attempts to link at least two 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.</i></p> <p>0 marks <i>The candidate does not make any attempt or give an answer worthy of credit.</i></p>						

Question			Marking details	Marks Available						
				AO1	AO2	AO3	Total	Maths	Prac	
10.	(c)	(i)	$f = \frac{3.00 \times 10^8}{515 \times 10^{-9}} = 5.83 \times 10^{14}$ (1) $E = 3.87 \times 10^{-19}$ (1) 233 kJ mol ⁻¹ (1) ecf possible award (3) for cao	1						
		(ii)	agree because total percentage of cobalt decreases / is less than 100% after the addition of ammonia (1) the equation shows cobalt will be in one of the two species / if the equation was correct the percentage in each complex would always add up to 100% (1) there must be another cobalt complex / an intermediate (1)		1					
Question 10 total				8	3	3	14	4	1	

Question			Marking details	Marks Available						
				AO1	AO2	AO3	Total	Maths	Prac	
12.	(a)		$\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$ / 1 mol H_2SO_4 : 2 mol NaOH (1) 0.341 mol dm ⁻³ (1) answer given to 3 significant figures (1)		1					
					1		1	3	1	3
	(b)		$[\text{H}^+] = 10^{-\text{pH}}$ (1) $[\text{H}^+] = 3.1623 \times 10^{-14}$ (1) $[\text{NaOH}] = 1.00 \times 10^{-14} \div 3.1623 \times 10^{-14} = 0.316 \text{ mol dm}^{-3}$		1					
					1			3	3	3
	(c)		titration is more precise as a change of 0.1 in pH gives a large change in concentration / the resolution of the burette or pipette is much greater than that of the pH probe					1	1	1
	(d)	(i)	phenolphthalein as the titration curve will be vertical in the range 8.2-10.0 / will not be vertical in the range 2.9-6.3 (1)					1	1	1
		(ii)	after addition of half the volume of sodium hydroxide there will be equal concentrations of ethanoic acid and sodium ethanoate / $[\text{ACID}] = [\text{SALT}]$ / $[\text{H}^+] = K_a$ (1) pH = 4.7 (1)	1						
					1			2	2	
	(e)		any pH value in the range 3.0-6.8 (1) the ammonium ion exists in equilibrium with NH_3 and H^+ so it increases $[\text{H}^+]$ in solution / some NH_4^+ breaks down releasing H^+ (1)						2	
									2	
Question 12 total				1	8	3	12	7	8	

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
13.	(a)	(i)	$\Delta_f H_{\text{products}} = [(2 \times -482) + (8 \times -286) + (2 \times -436)] \quad (1)$ $\Delta_f H_{\text{reactants}} = [(2 \times -813) + (5 \times -188) + (6 \times -92)] \quad (1)$ $\Delta H = -4016 - (-3118) = -1006 \text{ kJ mol}^{-1} \quad (1)$ $\Delta G = \Delta H - T\Delta S = -1006 - [298 \times (9 \div 1000)] = -1009 \text{ kJ mol}^{-1} \quad (1)$ emf for the reaction = $1.52 - 0.68 = 0.84 \text{ V} \quad (1)$ reaction is feasible as the value of ΔG is negative and the value of the emf is positive (1)		5	1	6	4	
		(ii)	electrochemical as this is a solution reaction whilst the Gibbs' free energy data is for the solids/liquids (1) should use standard conditions of 1 mol dm^{-3} concentration (1) and 298K temperature (1)			3	3		3

Question				Marking details	Marks Available						
					AO1	AO2	AO3	Total	Maths	Prac	
13.	(b)	(i)	I	<p>increase in pH by one unit is a decrease in $[H^+]$ by a factor of 10 (1)</p> <p>between lines 1 and 2 $[H^+]$ decreases by a factor of 10 and the rate decreases by a factor of 10 therefore it is first order with respect to $[H^+]$ (1)</p>			2	2	2		
			II	<p>rate = $k [H^+]^1 [CH_3COCH_3]^1 [Br_2]^0$ (1)</p> <p>$[H^+] = 10^{-pH}$ for any relevant pH value (1)</p> <p>$k = 1.7 \times 10^{-3}$ (1)</p> <p>units = $mol^{-1} dm^3 s^{-1}$ (1)</p>	1	1	1	4	4		
			III	<p>incorrect – gains no credit</p> <p>credit for explanation</p> <p>rate equation shows that rate determining step must involve one CH_3COCH_3 and one H^+ (which is not present in this mechanism) (2)</p> <p>or</p> <p>rate equation shows that rate determining step must involve CH_3COCH_3 and H^+ (which is not present in this mechanism) (1)</p>			2	2			
		(ii)		<p>less energy needed as you can use lower temperature or pressure (1)</p> <p>homogenous catalysts in same phase as reactants so difficult to separate (1)</p>	2			2			1
Question 13 total					3	7	9	19	10	4	

A2 UNIT 3: PHYSICAL AND INORGANIC CHEMISTRY**SUMMARY OF ASSESSMENT OBJECTIVES**

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
Section A	2	8	0	10	1	1
9.	9	5	3	17	6	1
10.	8	3	3	14	4	1
11.	1	3	4	8	0	8
12.	1	8	3	12	7	8
13.	3	7	9	19	10	4
TOTAL	24	34	22	80	28	23