COMPONENT 1: 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 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.

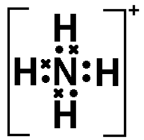
Marking abbreviations

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 <u>reversible</u> reaction where the forward and reverse reactions occur at the <u>same rate</u>	1			1		
2.	H_2O NH_3 CH_4 BF_3 must be in this order		1		1		
3.	 showing four shared pairs including one where **both** electrons have come from the nitrogen atom (ignore charge)		1		1		
4.	$\delta-$ O—H $\delta+$ $\delta-$ C—H $\delta+$ $\delta+$ B—Cl $\delta-$ $\delta+$ C=O $\delta-$ any two correct (1) all four correct (2)		2		2		
5.	xenon +2 0 reduction oxygen -2 0 oxidation each correct row (1) total (1) if all oxidation states correct but one or more error in oxidation/reduction column		2		2		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6.				$Mg_3(PO_4)_2$		1		1		
7.				**A** ice **B** caesium chloride - **both** correct (1)	1			1		
8.				$I_2 < Br_2 < Cl_2$ correct reason needed for credit greater degree of freedom leads to greater entropy / solids have lowest entropy **and** gases have highest entropy	1			1		
9.				$K_p = \frac{(NH_3)^2}{(N_2)(H_2)^3}$ (1) atm^{-2} (1)	1	1		2	1	
10.				$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ (1) $T_2 = \frac{25}{24} \times 298 = 310$ K (1)	1	1		2	1	
11.				$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$		1		1		
				Section A total	**5**	**10**	**0**	**15**	**2**	**0**

Section B

<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>12.</td><td>(a)</td><td>(i)</td><td></td><td><table><tr><th></th><th>Mass number</th><th>Symbol</th></tr><tr><td>Initial nuclide</td><td>194</td><td>Tl</td></tr><tr><td>Final nuclide</td><td>190</td><td>Pt</td></tr></table>
any two correct for (1)
all four correct for (2)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>radioactivity causes mutations / destroys or damages DNA (1)
alpha radiation most damaging / most ionising (1)

platinum has a long half-life so it emits radioactivity very slowly / bismuth emits radioactivity much more quickly (1)
^{190}Bi is the most damaging (1)</td><td>2</td><td></td><td>2</td><td>4</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td></td><td>Indicative content

• atomic spectrum contains series of discrete lines on a dark background
• these lines get closer together at higher energy until they overlap
• there are several series of lines
credit could be from a diagram

• energy released when electron falls to lower energy state
• discrete lines correspond to specific energies
• this suggests that electrons can only move between certain fixed levels
• frequency of light emitted corresponds to the difference between energy levels
• the lines get closer together at higher energy within a series because the electron energy levels get closer together</td><td>4</td><td></td><td>2</td><td>6</td><td></td><td></td></tr>
</table>

Question				Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks: Each point included clear link between observations and the proposed model *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.* **3-4 marks:** Sound description of spectrum (could be missing reference to several series); clear understanding that discrete lines correspond to specific energies *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.* **1-2 marks:** Attempt at description of spectrum; some reference to electron transitions and energy changes *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.* **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**
12.	*(b)*	(ii)		aluminium has gradual increase in ionisation energies (1) with jumps between 3^{rd} and 4^{th} ionisations and 11^{th} and 12^{th} ionisations (1) jumps occur as electrons are in different shells / link between 2,8,3 and graph arrangements (1)	1	2		3		
				Question 12 total	**7**	**4**	**4**	**15**	**0**	**0**

Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
					Marks available					
13.	*(a)*			sodium oxide gives colourless solution, magnesium oxide forms white precipitate (1) $Na_2O + H_2O \rightarrow 2NaOH$ (1) (accept $MgO + H_2O \rightarrow Mg(OH)_2$)	1	1		2		1
	(b)			add $CO_3^{2-}(aq)$ / $OH^-(aq)$ (1) NaCl gives colourless solution, $MgCl_2$ gives white precipitate (1)		2		2		2
	(c)			$Na^+(aq)$ and $Cl^-(aq)$ do not react with H_2O, therefore pH is 7 (1) $CH_3COO^-(aq)$ reacts with H_2O forming CH_3COOH and OH^-, therefore pH is greater than 7 (1)	2			2		
	(d)			$\Delta_f H = \Delta_{at}H$ Cu + I.E.Cu + $\Delta_{at}H$ F_2 + E.A.F + $\Delta_{lat\ form}H$ CuF_2 (1) doubling value for forming 2F and $2F^-$ (1) (accept from Born-Haber cycle) $\Delta_f H$ CuF_2 = 339 + 2705 + 158 – 696 – 3037 (1) $\Delta_f H$ CuF_2 = –531 kJ mol^{-1} (1) award (4) for correct answer only (cao) error carried forward (ecf) possible		4		4	4	
				Question 13 total	**3**	**7**	**0**	**10**	**4**	**3**

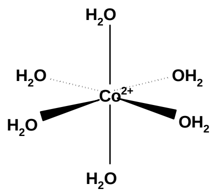
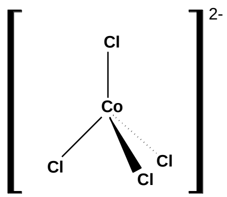
Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
					Marks available					
14.	*(a)*			pressure increases (1) number of gas molecules increases / more moles of gas on product side of equation (1)		2		2		
	(b)	(i)		when concentration doubles, rate doubles (1) therefore first order or rate is proportional to concentration (*must give reason to get this mark*) (1) **or** calculate values for *k* or rate/concentration ratios (1) state that these are constant (1)			1 1	2	1	
		(ii)		rate determining step must have one N_2O_5 molecule as reactant (1) mechanism A matches this rate equation (1) *(must give reason to get this mark)*			2	2		
	(c)			appropriate readings correctly made from graph e.g. $y = 4.4$; $x = 0.35 \times 10^{-3}$ (1) gradient = -12500 ± 500 (1) (*accept positive value*) $E_a = 12500 \times 8.31 = 103875$ (1) $E_a = 104$ (kJ mol^{-1}) (1) award (4) for cao award (3) for negative value or answer in J mol^{-1} ecf possible		1 1	1 1	4	4	
				Question 14 total	**0**	**4**	**6**	**10**	**5**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
15.	*(a)*			$\Delta H = 2 \times -286 + (-394) - (-239)$ (1)						
				$= -727$ ($kJ\ mol^{-1}$) (1)					1	
				$\Delta S = 2 \times 70 + 214 - 127 - 1\frac{1}{2} \times 206$ (1)						
				$= -82$ ($J\ K^{-1}\ mol^{-1}$) (1)		4			1	
				$\Delta G = [-727 - (298 \times -0.082)]$ (1)	1				1	
				$= -703$ ($kJ\ mol^{-1}$) (1)		1		6	1	
				award (5) for cao – AO1 mark withheld ecf possible						
	(b)			negative ΔG means reaction is feasible	1			1		
				Question 15 total	**2**	**5**	**0**	**7**	**4**	**0**

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
16.	*(a)*	(i)	$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$		1		1		
		(ii)	acidify with HNO_3(aq), then add $AgNO_3$(aq) (1) cream precipitate is formed (1)	2			2		2
	(b)	(i)	hydrogen chloride	1			1		1
		(ii)	sulfur dioxide	1			1		1
	(c)		$Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$ (1) chlorine is simultaneously oxidised and reduced (1) from oxidation state 0 to –1 and +1 (1)		3		3		
	(d)		$K_a = \frac{[H^+][CH_2ClCH_2COO^-]}{[CH_2ClCH_2COOH]}$ (1) $[CH_2ClCH_2COO^-] = 0.150$ mol dm^{-3} (1) $[H^+] = \frac{(7.94 \times 10^{-5})(0.1)}{0.150}$ (1) $[H^+] = 5.29 \times 10^{-5}$ pH $= -\log 5.29 \times 10^{-5} = 4.28$ (1) ecf possible	1 (for $[H^+]$ expression)	1 (for K_a) 1 (for $[CH_2ClCH_2COO^-]$) 1 (for pH)		4	1 (for $[CH_2ClCH_2COO^-]$) 1 (for $[H^+]$ expression) 1 (for pH)	4

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
16.	*(e)*			solution contains a large amount of CH_2ClCH_2COOH and $CH_2ClCH_2COO^-$ ions (accept correct equations) (1) when an acid is added, the $CH_2ClCH_2COO^-$ ions react with the H^+ ions, removing them from solution and keeping the pH constant (1) when an alkali is added, the CH_2ClCH_2COOH reacts with the OH^- ions, removing them from solution and keeping the pH constant (accept answer in terms of H^+ ions reacting with OH^- ions) (1)	3			3		
				Question 16 total	**8**	**7**	**0**	**15**	**3**	**8**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
17.	*(a)*			sample contains potassium ions / Q or Z are potassium / K			1	1		1
	(b)	(i)		to ensure that all the water has been lost	1			1		1
		(ii)		1.081 / 18.02 = 0.06 mol (1) 0.06 moles water in 0.01 mol compound, so x = 6 (1) no ecf			2	2	2	
	(c)	(i)		$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$		1		1		
		(ii)		excess needed to ensure that all the sulfate has been precipitated (1) add more barium chloride to filtrate to ensure there is no more precipitate formed / calculate volume needed and measure and add excess (1)		2		2		2
		(iii)		25 × 0.1 ÷ 1000 = 0.0025 mol of schönite (1) moles barium sulfate = 1.166 / 233.1 = 0.005 (1) y = 0.005 / 0.0025 = 2 (1)			3	3	3	
	(d)			formula is $K_2Mg(SO_4)_2.6H_2O$ (2) award (1) for identification of Mg if answer incorrect			2	2		
				Question 17 total	**1**	**3**	**8**	**12**	**5**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
18.	*(a)*			 (1)  (1) award (1) only if ligands correct but no attempt at 3D representation of bonds	2			2		
	(b)	(i)		$f = \frac{3.00 \times 10^{8}}{590 \times 10^{-9}} = 5.08 \times 10^{14}$ (Hz) (1) $E = 3.37 \times 10^{-19}$ (J) (1) award (2) for cao ecf possible		2		2	2	
		(ii)		Indicative content • $[CoCl_4]^{2-}$ – red light is absorbed (shown in spectrum) • ligands cause splitting of *d*-orbitals into higher and lower energy levels • Co has a vacancy in the higher energy level • electrons in the lower level can absorb energy to move to the higher level • energy difference between higher and lower energy levels corresponds to the frequency/wavelength of red light credit awarded for an appropriately labelled diagram	5		1	6		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks: Each point addressed, including one reference to red light; explanation in correct order; no reference to emission of blue light *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.* **3-4 marks:** Reference to splitting of *d*-orbitals by ligands; absorption of energy corresponding to difference between levels *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.* **1-2 marks:** Splitting of d-orbitals; electrons move to another energy level; energy change corresponds to colour *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.* **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
18.	*(b)*	(iii)		value determined from graph – 0.067 ± 0.001 (1) calculated value = 0.06525 (given to min 3 sig figs) (1) graph does not give as precise an answer / precision lost using graph / mathematical equation gives answer to the same number of significant figures as absorption (1)		2	1	3	1	3
	(c)	(i)		$K_c = \dfrac{[(CoCl_4)^{2-}]\,[H_2O]^6}{[(Co(H_2O)_6)^{2+}]\,[Cl^-]^4}$		1		1		
		(ii)		concentration of H_2O = 0.48 mol dm^{-3} concentration of $[Co(H_2O)_6]^{2+}$ = 0.12 mol dm^{-3} concentration of Cl^- = 0.18 mol dm^{-3} all three concentrations stated explicitly or shown in equation (2) any one (1) $K_c = 7.77$ (1) award (3) for cao $mol^2\ dm^{-6}$ (1)	1	3		4	4	
	(d)			cloudiness is white precipitate / precipitate formed by reaction of chloride with silver ions/ insoluble silver chloride (1) concentration of chloride ions decreased significantly (1) equilibrium will shift to left hand side according to Le Chatelier's principle / to produce more chloride ions / to replace chloride ions removed (1) more $[Co(H_2O)_6]^{2+}$ formed / $[CoCl_4]^{2-}$ converted to $[Co(H_2O)_6]^{2+}$ and these are different colours / leading to colour change (1)		1 1	1 1	4		4
				Question 18 total	**8**	**10**	**4**	**22**	**7**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
19.	*(a)*	(i)		any two for (1) each up to max 2 • eye protection for solution spillage when filling burette (1) • care to avoid burns whilst heating (1) • wear lab coat as sulfuric acid is corrosive, potassium manganate(VII) stains clothing (1)	2			2		2
		(ii)		mean titre = (15.00 + 14.90 + 14.95) ÷ 3 = 14.95 (1) moles MnO_4^- = 0.020 × 0.01495 = 2.99×10^{-4} moles Fe^{2+} = 1.495×10^{-3} (1) conc Fe^{2+} = $1.495 \times 10^{-3}/0.025$ = 0.0598 mol dm^{-3} (1) award (3) for cao ecf possible		1 1 1		3	1 1	3
		(iii)		moles MnO_4^- = 0.020 × 0.0191 = 3.82×10^{-4} (1) moles Fe^{2+} = 1.91×10^{-3} moles Fe^{3+} = $1.91 \times 10^{-3} - 1.495 \times 10^{-3} = 4.15 \times 10^{-4}$ (1) conc Fe^{3+} = $4.15 \times 10^{-4}/0.025$ = 0.0166 mol dm^{-3} (1) award (3) for cao ecf possible **or** conc Fe^{2+} = $1.91 \times 10^{-3}/0.025$ = 0.0764 mol dm^{-3} (2) conc Fe^{3+} = 0.0764 – 0.0598 = 0.0166 mol dm^{-3} (1)		1	1 1	3	3	3

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
19.	*(a)*	(iv)		burette accurate to ± 0.10, therefore apparatus error about 1% (1) three results are reliable since they are within 0.10 cm^3 of each other (1) improve accuracy by using an instrument to measure permanent colour change rather than visual estimation (1)			3	3		3
	(b)			any three for (1) each up to max 3 Method **A** would produce a result with a low Fe^{2+} concentration since: • reduction of Fe^{3+} might not be complete (1) • Fe^{2+} might re-oxidise to Fe^{3+} prior to titration (1) • there is no guarantee of complete transfer of Fe^{2+} following reduction (1) • Method **B** depends on use of digital apparatus so should be more accurate (1)			3	3		3
				Question 19 total	**2**	**4**	**8**	**14**	**5**	**14**

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	2	0
12.	7	4	4	15	0	0
13.	3	7	0	10	4	3
14.	0	4	6	10	5	0
15.	2	5	0	7	4	0
16.	8	7	0	15	3	8
17.	1	3	8	12	5	4
18.	8	10	4	22	7	7
19.	2	4	8	14	5	14
Totals	**36**	**54**	**30**	**120**	**35**	**36**