



Oxford Cambridge and RSA

...day June 20XX – Morning/Afternoon

A Level Chemistry A

H432/01 Periodic table, elements and physical chemistry

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

SPECIMEN

This document consists of 24 pages

MARKING INSTRUCTIONS**PREPARATION FOR MARKING****SCORIS**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal <http://www.rm.com/support/ca>
3. Log-in to scoris and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
- where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
 - if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.
6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.
7. There is a NR (No Response) option. Award NR (No Response)
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.
- Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).
8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
- If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in *italics*) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in *italics*) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **19(d)** and **22(b)**.

11. Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

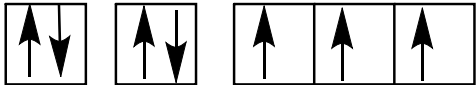
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

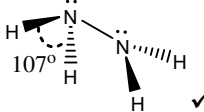
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

SECTION A

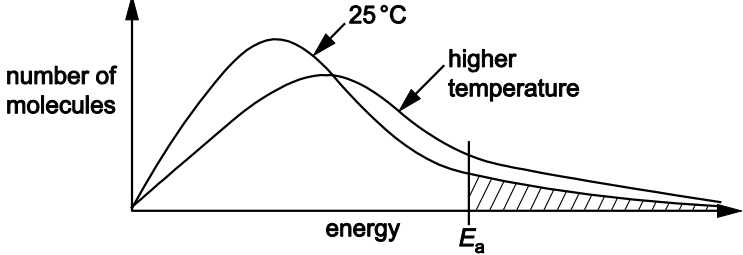
Question	Answer	Marks	Guidance
1	A	1	
2	B	1	
3	C	1	
4	D	1	
5	C	1	
6	D	1	
7	C	1	
8	D	1	
9	C	1	
10	C	1	
11	A	1	
12	D	1	
13	D	1	
14	B	1	
15	D	1	
	Total	15	

SECTION B

Question	Answer	Marks	Guidance
16 (a)	 2s 2p	2	ALLOW half headed arrows
(b)	The forward reaction is exothermic, so an increase in temperature favours the backward reaction (<i>owtte</i>) ... ✓ ... therefore there will be more N₂ and H₂ OR less NH₃ in the equilibrium mixture, AND therefore the value of the equilibrium constant will decrease (<i>owtte</i>) ✓	2	ALLOW names of compounds ALLOW reactants/product instead of compounds 2nd mark only available if deduced from 1st mark ALLOW ECF for 2nd mark
(c)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $2.37 \times 10^{-6} \text{ kPa}^{-2}$ award 5 marks IF answer = 2.37×10^{-6} with incorrect units award 4 marks At equilibrium, $n(\text{H}_2) = 0.300 \text{ (mol)}$ AND $n(\text{NH}_3) = 0.100 \text{ (mol)}$ ✓ $p(\text{N}_2) = \frac{0.400}{0.800} \times 500 = 250 \text{ kPa}$ AND $p(\text{H}_2) = \frac{0.300}{0.800} \times 500 = 187.5 \text{ kPa}$ AND $p(\text{NH}_3) = \frac{0.100}{0.800} \times 500 = 62.5 \text{ kPa}$ ✓ $K_p = \frac{p(\text{NH}_3)^2}{p(\text{N}_2) \times p(\text{H}_2)^3} = \frac{62.5^2}{250 \times 187.5^3}$ ✓ $= 2.37 \times 10^{-6}$ ✓ kPa^{-2} ✓	5	Final answer must be correct and have the correct units to score all five marks ALLOW calculator value for K_p correctly rounded to three or more significant figures. If there is an alternative answer, check to see if there is any ECF credit possible using working below Correct values substituted into correct expression for K_p gains first three marks.

Question	Answer	Marks	Guidance
(d)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2580 (tonnes) award 3 marks $n(\text{NH}_3) = \frac{1.96 \times 10^{10}}{24}$ OR 8.167×10^8 (mol) AND $n(\text{H}_2) = \frac{8.167 \times 10^8}{2} \times 3 = 1.225 \times 10^9$ (mol) ✓ Mass of $\text{H}_2 = \frac{2.450 \times 10^9}{1 \times 10^6} = 2450$ (tonnes) ✓ Mass of H_2 for 95% yield = $\frac{2450 \times 100}{95} = 2580$ (tonnes) ✓	3	If there is an alternative answer, check to see if there is any ECF credit possible using working below ALLOW 2.58×10^3 tonnes AW 100% yield = $2.063 \times 10^{10} \text{ dm}^3$ ✓ Amount of $\text{NH}_3 = 8.596 \times 10^8$ mol AND Amount of $\text{H}_2 = 1.289 \times 10^9$ mol ✓ Mass of $\text{H}_2 = 2580$ (tonnes) ✓ ALLOW 2579 (tonnes) (calculator answer rounded to nearest whole number)
(e) (i)	$2\text{NH}_3 + \text{NaOCl} \rightarrow \text{N}_2\text{H}_4 + \text{NaCl} + \text{H}_2\text{O}$ ✓	1	
(ii)	 Bond angle 107° ✓	2	Diagram must attempt to show geometry around the nitrogen atom to be pyramidal ALLOW $106-108^\circ$
	Total	15	

Question			Answer	Marks	Guidance
17	(a)	(i)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = $0.163 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ OR $0.1632 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ award 4 marks IF answer = 0.163 OR 0.1632 with incorrect units award 3 marks Order w.r.t. ICl = 1 and order w.r.t H_2 = 1 ✓ rate = $k[\text{ICl}][\text{H}_2]$ ✓ $k = \frac{2.04 \times 10^{-2}}{0.250 \times 0.500} = 0.163$ OR 0.1632 ✓ $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ ✓	4	If there is an alternative answer, check to see if there is any ECF credit possible using working below Both orders = 1 mark Correct rate equation or rearranged form = 1 mark Candidates may use experimental data from experiments 2 or 3 to calculate the rate constant DO NOT ALLOW 0.16
		(ii)	rate = $k[\text{ICl}][\text{H}_2]$ (from (i)) = $0.163 \times 3 \times 10^{-3} \times 2 \times 10^{-3} = 9.78 \times 10^{-7} \text{ (mol dm}^{-3} \text{ s}^{-1})$ ✓	1	ALLOW ECF from (i) Note use of 0.1632 from (i) gives $9.79(2) \times 10^{-7}$

Question	Answer	Marks	Guidance
(b)	 number of molecules 25°C higher temperature energy E_a Correct curve for higher temperature ✓ Activation energy shown on diagram AND graph shows that at higher temperature (<i>owtte</i>) more molecules have energy above activation energy OR more molecules have enough energy to react ✓	2	Boltzmann distribution – must start at origin and must not end up at 0 on y-axis i.e. must not touch x-axis at high energy Maximum of curve to right AND lower than maximum of lower temperature curve AND above lower temp line at higher energy as shown in diagram link to graph required for mark
	Total	7	

Question	Answer	Marks	Guidance
18	ΔH calculation from experiment $q = 100 \times 4.18 \times 20.5$ OR 8569 J OR 8.569 kJ ✓ Amount of butan-1-ol = $\frac{0.259}{74} = 3.5 \times 10^{-3}$ mol ✓ $\Delta H = -2448$ kJ mol⁻¹ ✓ ΔS calculation $\Delta S = S_{\text{products}} - S_{\text{reactants}}$ $\Delta S = (4 \times 214) + (5 \times 70) - [(228) + (6 \times 205)]$ OR $\Delta S = 1206 - 1458$ ✓ $\Delta S = -252$ J K⁻¹ mol⁻¹ OR -0.252 kJ K⁻¹ mol⁻¹ ✓ ΔG calculation $\Delta G = \Delta H - T\Delta S$ $\Delta G = -2448 - (298 \times -0.252)$ ✓ $\Delta G = -2373$ (kJ mol⁻¹) ✓	7	ALLOW Calculator value for $\Delta H = -2448.285714$ correctly rounded to three or more significant figures Mark for use of correct expression with ΔS in kJ K⁻¹ mol⁻¹ ALLOW three or more sig figs for ΔG
	Total	7	

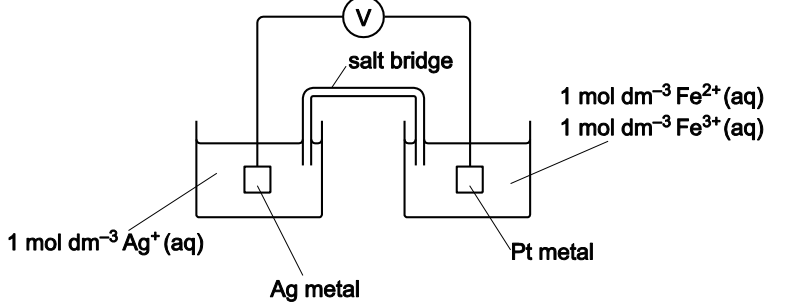
Question			Answer	Marks	Guidance
19	(a)		$\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$ ✓ Effervescence AND solid dissolves ✓	2	State symbols are required ALLOW solid disappears
	(b)		Lattice enthalpy of MgCl_2 is more exothermic than CaCl_2 ... ✓ because magnesium ion/ Mg^{2+} is smaller (than calcium ions/ Ca^{2+}) OR Mg^{2+} has a greater charge density ... ✓ ... therefore the attraction between Mg^{2+} and Cl^- is greater (than between Ca^{2+} and Cl^-) ✓	3	ORA throughout ALLOW 'charge density' here only ALLOW magnesium/Mg is smaller DO NOT ALLOW Mg^{2+} has a smaller atomic radius DO NOT ALLOW chlorine ions DO NOT ALLOW Mg has greater attraction ALLOW 'attracts with more force' for greater attraction but DO NOT ALLOW 'greater force' (could be repulsion)
	(c)	(i)	F B E D G FIVE correct FOUR correct THREE correct ✓✓✓ ✓✓ ✓	3	ALLOW 1450 736 G 76 -642 IF only one or two correct, award 0 marks.
		(ii)	$-642 - (+76 + (2 \times 150) + 736 + 1450 + (2 \times -349))$ ✓ $-642 - 1864 = -2506$ ✓ (kJ mol^{-1})	2	ALLOW for 1 mark: -2705 (2 x 150 and 2 x 349 not used for Cl) -2356 (2 x 150 not used for Cl) -2855 (2 x 349 not used for Cl) $+2506$ (wrong sign) DO NOT ALLOW any other answers

Question	Answer	Marks	Guidance
(d)*	<i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Describes and explains concisely the trend in reactivity of the halogens AND Full observations of redox reactions backed up by at least two equations <i>There is a well-developed explanation which is clear and logically structured. The observations and equations are relevant to those trends explained. Clear and confident knowledge of relevant technical language.</i> Level 2 (3–4 marks) Describes and explains the trend in reactivity of the halogens AND Is able to recall a redox reaction by suitable observations and correctly link to an equation <i>There is an explanation with some structure. The observations and equations are in the most-part relevant to the trend explained. Sound grasp of relevant technical language.</i> Level 1 (1–2 marks) Describes the trend in reactivity of the halogens with some attempt at explanation AND Is able to recall a redox reaction either by suitable observation or by equation	6	Indicative scientific points may include: Trend in reactivity • More shells or increasing radius down the group • Increased shielding down the group • More difficult to gain an electron Observations • Reaction of Cl_2 or Br_2 with I^-: orange/brown solution OR purple in organic • Reaction of Cl_2 with Br^-: yellow solution OR orange in organic Reaction equations • $\text{Cl}_2 + 2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{Cl}^-$ • $\text{Cl}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Cl}^-$ OR $\text{Br}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Br}^-$ • Order of reactivity linked to observations

Question			Answer	Marks	Guidance
			<i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.		
			Total	16	

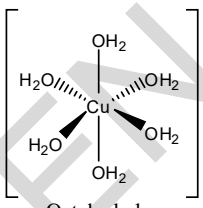
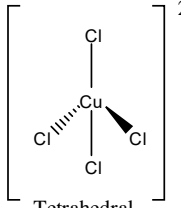
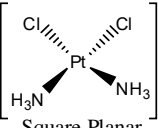
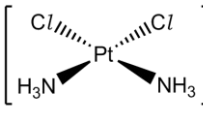
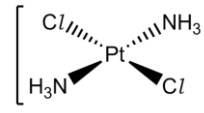
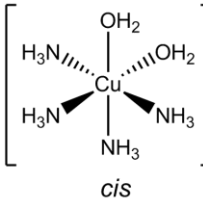
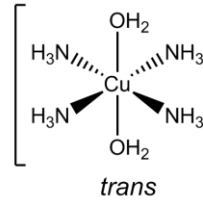
Question	Answer	Marks	Guidance
20 (a)	$[H^+] = 10^{-pH} = 10^{-2.19} = 6.46 \times 10^{-3} \text{ (mol dm}^{-3}\text{)} \checkmark$ $[CH_3CH(OH)COOH] = \frac{[H^+]^2}{K_a} = \frac{(6.46 \times 10^{-3})^2}{1.38 \times 10^{-4}} \checkmark$ $= 0.0302 \text{ (mol dm}^{-3}\text{)} \checkmark$ $n(CH_3CH(OH)COOH) = \frac{0.302 \times 250}{1000} = 0.0755 \text{ mol} \checkmark$ Mass of $CH_3CH(OH)COOH = 0.0755 \times 90 = 6.80 \text{ g} \checkmark$ Dissolve 6.80 g of the solid in distilled water (less than 250 cm³) in a beaker $\checkmark$ (then) transfer the solution to a 250 cm³ volumetric flask AND ensure that all solution is washed out of beaker (washings transferred to volumetric flask) $\checkmark$ (then) make solution up to 250 cm³ with distilled water AND ensure thorough mixing by inverting the flask several times $\checkmark$	8	ALLOW 5 marks for 6.80 g through any calculation. ALLOW ECF for incorrect calculation of mass. Mass used must be linked to calculation.
(b)	$CH_3CH(OH)COO^- + CH_3CH_2CH_2COOH_2^+ \checkmark$ $CH_3CH(OH)COOH$ AND $CH_3CH(OH)COO^-$ $CH_3CH_2CH_2COOH$ AND $CH_3CH_2CH_2COOH_2^+$ Both pairs identified $\checkmark$	2	State symbols NOT required ALLOW labels 'acid 1', 'base 1' etc. ALLOW ECF for second mark

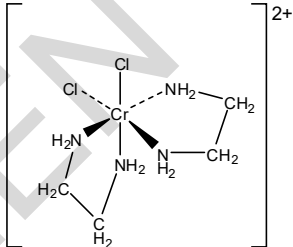
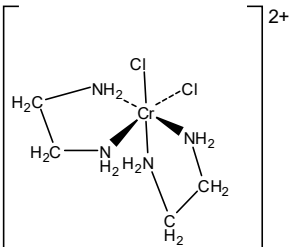
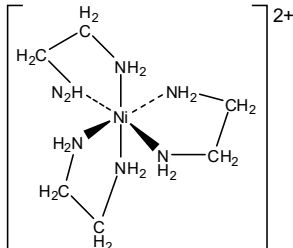
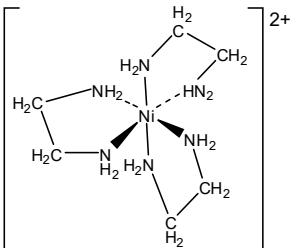
Question	Answer	Marks	Guidance
(c) (i)	$[H^+] = \frac{1 \times 10^{-14}}{0.185} = 5.405 \times 10^{-14} \text{ (Use of } K_w) \checkmark$ $pH = -\log(5.405 \times 10^{-14}) = 13.27 \checkmark$	2	ALLOW $5.405405405 \times 10^{-14}$ and correct rounding to 5.4×10^{-14} ALLOW alternative approach using pOH: $pOH = -\log(0.185) = 0.73$ $pH = 14 - 0.73 = 13.27$ Correct answer scores BOTH marks ALLOW 13.267
(ii)	$n(A^-) = 9.25 \times 10^{-3} \text{ (mol)} \checkmark$ $n(HA) = 0.0165 - 9.25 \times 10^{-3} = 7.25 \times 10^{-3} \text{ (mol)} \checkmark$ $[H^+] = K_a \times \frac{[HA]}{[A^-]} \checkmark$ $pH = -\log(1.5 \times 10^{-5} \times \frac{0.058}{0.074}) = 4.93$ $\text{OR } pH = -\log(1.5 \times 10^{-5} \times \frac{1000 \times \frac{7.25 \times 10^{-3}}{125}}{1000 \times \frac{9.25 \times 10^{-3}}{125}}) = 4.93 \checkmark$ Final mark also via Henderson–Hasselbalch equation: $pH = pK_a - \log \frac{[HA]}{[A^-]} = 4.82 - (-0.11) = 4.93$ OR $pH = pK_a + \log \frac{[A^-]}{[HA]} = 4.82 + 0.11 = 4.93 \checkmark$	4	ALLOW HA/acid and A⁻/salt throughout for butanoate and butanoic acid ALLOW $pK_a = -\log K_a$ OR $-\log 1.5 \times 10^{-3}$ OR 4.82 ALLOW ECF from incorrect values of $n(A^-)$ or $n(HA)$ ALLOW $pH = -\log(1.5 \times 10^{-5} \times \frac{7.25 \times 10^{-3}}{9.25 \times 10^{-3}}) = 4.93$
	Total	16	

Question	Answer	Marks	Guidance
21 (a) (i)	 Half-cells (2 marks) Ag(s) and 1 mol dm⁻³ Ag⁺(aq) ✓ 1 mol dm⁻³ Fe²⁺(aq) AND 1 mol dm⁻³ Fe³⁺(aq) AND Pt metal ✓ Complete circuit (1 mark) salt bridge AND voltmeter AND wires ✓ Standard conditions (1 mark) 298 K / 25 °C AND 100 kPa / 101 kPa pressure ✓	4	ALLOW 1 atm
	(ii) (Electrode potential of) Ag⁺/Ag becomes more positive ... ✓ therefore, E_{cell} becomes smaller OR less positive. ✓	2	ALLOW equilibrium Ag/Ag⁺ shifts to right ALLOW more negative 2nd mark only available if deduced from 1st mark ALLOW ECF for 2nd mark

Question			Answer	Marks	Guidance
	(b)		Ce ³⁺ and Zn ²⁺ ✓	1	
	(c)		Mn ²⁺ , H ₂ O, Fe ³⁺ , Br ₂ Three species correct ✓ Four species correct ✓	2	
			Total	9	

Question	Answer	Marks	Guidance
22 (a)	1. $n(\text{AgCl}) \text{ formed} = \frac{7.695}{143.5} = 0.05362 \text{ (mol)} \checkmark$ 2. 0.0180 mol of B forms 0.05362 mol of Cl^- No of Cl^- ions in formula of B = $\frac{0.05362}{0.0180} = 3 \checkmark$ 3. Molar mass of B = $\frac{2.856}{0.0180} = 158.7 \text{ (g mol}^{-1}\text{)} \checkmark$ $158.7 - (3 \times 35.5) = 52.2$ which is chromium $\checkmark$ 4. $n(\text{H}_2\text{O}) = \frac{1.944}{18} = 0.108 \text{ (mol)}$ 0.0180 mol CrCl_3: 0.108 mol H_2O OR 1 mol CrCl_3: 6 mol $\text{H}_2\text{O} \checkmark$ A $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ (from points 2, 3 and 4) $\checkmark$ B CrCl_3 (from points 2 and 3) $\checkmark$ D $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ (from determination of A and understanding of reaction with water) $\checkmark$ E $\text{Cr}(\text{OH})_3$ (from understanding of reaction of D with aqueous hydroxide) $\checkmark$	9	ALLOW Alternative working throughout

Question	Answer	Marks	Guidance
(b)*	<i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Links together names of shapes with correct 3-D diagrams AND Appreciates the two different types of isomerism and labels diagrams appropriately <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> <i>Demonstrates clear and confident knowledge of relevant technical language using the terms</i> <i>non-superimposable mirror images within optical isomerism</i> <i>opposite and adjacent/same side in cis–trans</i> Level 2 (3–4 marks) Names and labels at least two of the shapes appropriately giving 3-D diagrams AND Appreciates that two types of isomerism exist in transition metal chemistry, gives diagrams to illustrate at least one pair of isomers and names them correctly <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> <i>Answers question with a sound grasp of relevant technical language using the terms</i>	6	Indicative scientific points may include: Shapes of complex ions • six coordinate bonds: octahedral • four coordinate bonds: tetrahedral or square planar • 3-D diagrams with charges linked to shapes  Octahedral  Tetrahedral  Square Planar cis–trans isomerism • found in octahedral and square planar complexes • <i>trans</i> – opposite; <i>cis</i> – adjacent / same side • 3-D diagrams to illustrate  <i>cis</i>  <i>trans</i> OR  <i>cis</i>  <i>trans</i>

Question	Answer	Marks	Guidance
	<i>tetrahedral, octahedral</i> <i>cis–trans OR optical</i> Level 1 (1–2 marks) Names and draws structures of two of the shapes AND Appreciates one type of isomerism that can be seen in transition metal chemistry <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> <i>Answers question with a basic grasp of relevant technical language</i> <i>links octahedral to six ligands and tetrahedral to four ligands either in word or by diagram</i> <i>correctly links one type of isomerism to a structure</i> 0 marks No response or no response worthy of credit.		Optical isomerism - Found in octahedral complexes when bidentate ligands are present - Isomers are non-superimposable mirror images 3-D diagrams to illustrate   OR  
	Total	15	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions

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