OCR
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

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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.

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5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. 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.

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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)**.

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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

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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.

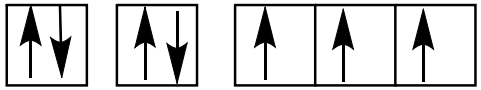
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SECTION A

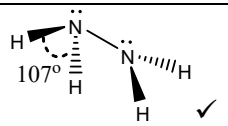
Question	Answer	Marks	Guidance
1	A	1	
2	B	1	
3	C	1	
4	D	1	
5	C	1	
6	D	1	
7	C	1	
8	D	1	
9	C	1	
10	C	1	
11	A	1	
12	D	1	
13	D	1	
14	B	1	
15	D	1	
	Total	15	

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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 (*owtte*) … ✓ … therefore there will be more N_2 and H_2 **OR** less NH_3 in the equilibrium mixture, **AND** therefore the value of the equilibrium constant will decrease (*owtte*) ✓	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 = 2.37×10^{-6} kPa^{-2} award 5 marks **IF** answer = 2.37×10^{-6} with incorrect units award 4 marks At equilibrium, $n(H_2) = 0.300$ (mol) **AND** $n(NH_3) = 0.100$ (mol) ✓ $p(N_2) = \frac{0.400}{0.800} \times 500 = 250$ kPa **AND** $p(H_2) = \frac{0.300}{0.800} \times 500 = 187.5$ kPa **AND** $p(NH_3) = \frac{0.100}{0.800} \times 500 = 62.5$ kPa ✓ $K_p = \frac{p(NH_3)^2}{p(N_2) \times p(H_2)^3} = \frac{62.5^2}{250 \times 187.5^3}$ ✓ $= 2.37 \times 10^{-6}$ ✓ 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.

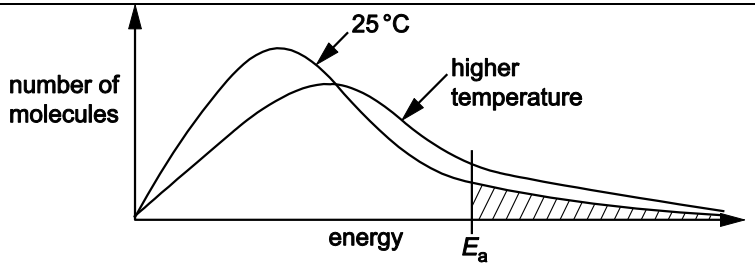
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Question			Answer	Marks	Guidance
	(d)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = 2580 (tonnes) award 3 marks $n(NH_3) = \frac{1.96 \times 10^{10}}{24}$ **OR** 8.167×10^8 (mol) **AND** $n(H_2) = \frac{8.167 \times 10^8}{2} \times 3 = 1.225 \times 10^9$ (mol) ✓ Mass of $H_2 = \frac{2.450 \times 10^9}{1 \times 10^6} = 2450$ (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 = 2.063×10^{10} dm^3 ✓ Amount of $NH_3 = 8.596 \times 10^8$ mol **AND** Amount of $H_2 = 1.289 \times 10^9$ mol ✓ Mass of H_2 = 2580 (tonnes) ✓ **ALLOW** 2579 (tonnes) (calculator answer rounded to nearest whole number)
	(e)	(i)	$2NH_3 + NaOCl \rightarrow N_2H_4 + NaCl + H_2O$ ✓	1	
		(ii)	 ✓ Bond angle 107° ✓	2	Diagram must attempt to show geometry around the nitrogen atom to be pyramidal **ALLOW** 106–108°
			Total	15	

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Question			Answer	Marks	Guidance
17	(a)	(i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = 0.163 $dm^3\ mol^{-1}\ s^{-1}$ **OR** 0.1632 $dm^3\ mol^{-1}\ s^{-1}$ award 4 marks **IF** answer = 0.163 **OR** 0.1632 with incorrect units award 3 marks Order w.r.t. IC*l* = 1 and order w.r.t H_2 = 1 ✓ rate = k[IC*l*][H_2] ✓ $k = \frac{2.04 \times 10^{-2}}{0.250 \times 0.500}$ = 0.163 **OR** 0.1632 ✓ $dm^3\ mol^{-1}\ s^{-1}$ ✓	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[IC*l*][H_2] (from **(i)**) = $0.163 \times 3 \times 10^{-3} \times 2 \times 10^{-3} = 9.78 \times 10^{-7}$ ($mol\ dm^{-3}\ s^{-1}$) ✓	1	**ALLOW ECF** from **(i)** Note use of 0.1632 from **(i)** gives $9.79(2) \times 10^{-7}$

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Question			Answer	Marks	Guidance
	(b)		 Correct curve for higher temperature ✓ Activation energy shown on diagram **AND** graph shows that at higher temperature (*owtte*) 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**	

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

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Question			Answer	Marks	Guidance
19	(a)		$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ ✓ 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** **G** **E** **D** **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 × 150) + 736 + 1450 + (2 × –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

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Question	Answer	Marks	Guidance
(d)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **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 *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.* **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 *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.* **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** • $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ • $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$ **OR** $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ • Order of reactivity linked to observations

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

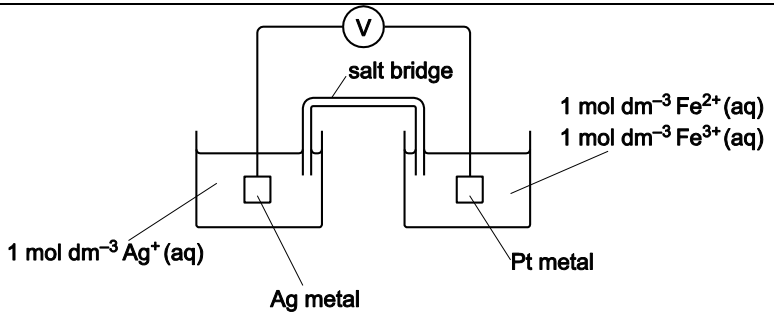
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Question			Answer	Marks	Guidance
20	(a)		$[H^+] = 10^{-pH} = 10^{-2.19} = 6.46 \times 10^{-3}$ (mol dm^{-3}) ✓ $[CH_3CH(OH)COOH] = \frac{[H^+]^2}{K_a} = \frac{(6.46 \times 10^{-3})^2}{1.38 \times 10^{-4}}$ ✓ $= 0.0302$ (mol dm^{-3}) ✓ $n(CH_3CH(OH)COOH)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

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Question			Answer	Marks	Guidance
	(c)	(i)	$[H^+] = \frac{1 \times 10^{-14}}{0.185} = 5.405 \times 10^{-14}$ (Use of K_w) ✓ pH = –log(5.405×10^{-14}) = 13.27 ✓	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)	$n(A^-) = 9.25 \times 10^{-3}$ (mol) ✓ n(HA) = 0.0165 – 9.25×10^{-3} = 7.25×10^{-3} (mol) ✓ $[H^+] = K_a \times \frac{[HA]}{[A^-]}$ ✓ pH = –log($1.5 \times 10^{-5} \times \frac{0.058}{0.074}$) = 4.93 **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 ✓ **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 ✓	4	**ALLOW** HA/acid and A^-/salt throughout for butanoate and butanoic acid **ALLOW** $pK_a = -\log K_a$ **OR** –log 1.5×10^{-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	

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Question			Answer	Marks	Guidance
21	(a)	(i)	 **Half-cells (2 marks)** Ag(s) and 1 mol dm^{-3} Ag^{+}(aq) ✓ 1 mol dm^{-3} Fe^{2+}(aq) **AND** 1 mol dm^{-3} Fe^{3+}(aq) **AND** Pt metal ✓ **Complete circuit (1 mark)** salt bridge **AND** voltmeter **AND** wires ✓ **Standard conditions (1 mark)** 298 K / 25 ºC **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

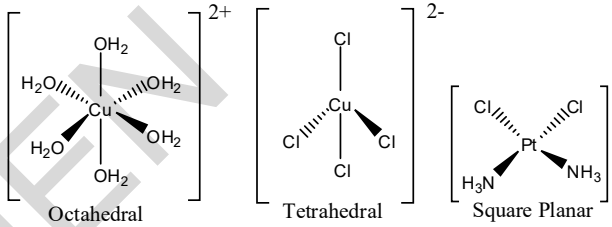
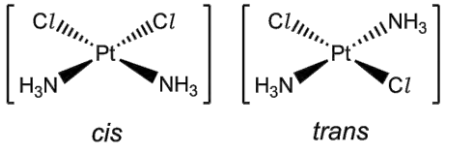
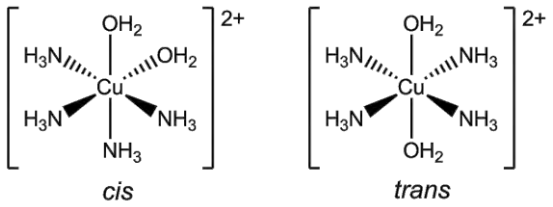
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Question			Answer	Marks	Guidance
	(b)		Ce^{3+} and Zn^{2+} ✓	1	
	(c)		Mn^{2+}, H_2O, Fe^{3+}, Br_2 Three species correct ✓ Four species correct ✓	2	
			Total	9	

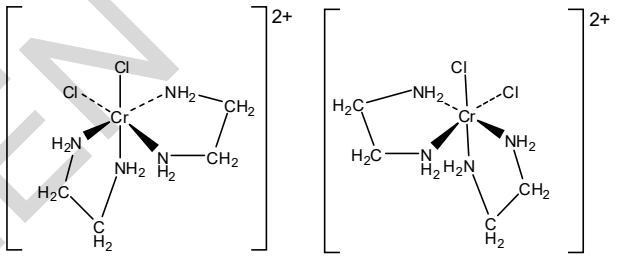
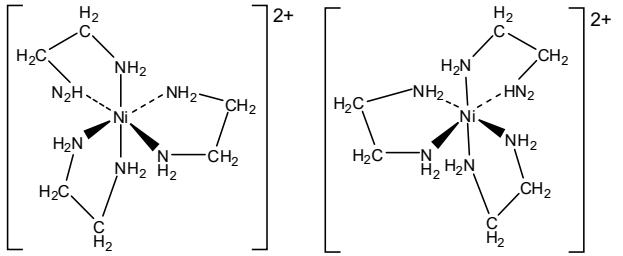
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Question			Answer	Marks	Guidance
22	(a)		1. $n(AgCl)$ formed $= \frac{7.695}{143.5} = 0.05362$ (mol) ✓ 2. 0.0180 mol of **B** forms 0.05362 mol of Cl^- No of Cl^- ions in formula of **B** $= \frac{0.05362}{0.0180} = 3$ ✓ 3. Molar mass of **B** $= \frac{2.856}{0.0180}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

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Question	Answer	Marks	Guidance
(b)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **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 *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* *Demonstrates clear and confident knowledge of relevant technical language using the terms* • *non-superimposable mirror images within optical isomerism* • *opposite and adjacent/same side in cis–trans* **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 *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* *Answers question with a sound grasp of relevant technical language using the terms*	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  **_cis–trans_ isomerism** • found in octahedral and square planar complexes • *trans* – opposite; *cis* – adjacent / same side • 3-D diagrams to illustrate  **OR** 

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Question	Answer	Marks	Guidance
	• *tetrahedral, octahedral* • *cis–trans **OR** optical* **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 *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* *Answers question with a basic grasp of relevant technical language* • *links octahedral to six ligands and tetrahedral to four ligands either in word or by diagram* • *correctly links one type of isomerism to a structure* **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**	

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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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