OCR
Oxford Cambridge and RSA

Practice paper – Set 2

A Level Chemistry A
H432/01 Periodic table, elements and physical chemistry

MARK SCHEME

Duration: 2 hour 15 minutes

MAXIMUM MARK 100

Final

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM 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.

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

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 RM Assessor 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 RM Assessor messaging system.

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 RM Assessor **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 RM Assessor 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 **17(a)** and **20(a)**.

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**.

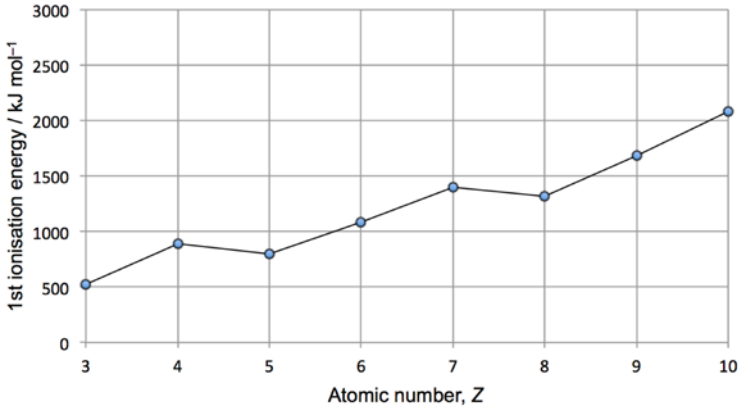
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

SECTION A

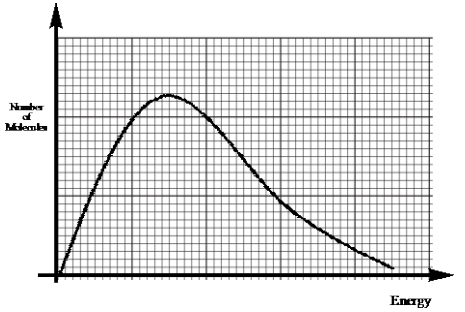
Question	Answer	Marks	Guidance
1	C	1	
2	D	1	
3	C	1	
4	C	1	
5	C	1	
6	B	1	
7	C	1	
8	B	1	
9	B	1	
10	D	1	
11	A	1	
12	B	1	
13	D	1	
14	B	1	
15	C	1	
	Total	15	

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	<table><tr><th>Isotope</th><th>Protons</th><th>Neutrons</th><th>Electrons</th></tr><tr><td>^{48}Ti</td><td>…22...</td><td>…26….</td><td>…22….</td></tr><tr><td>…$^{46}Ti^{3+}$..</td><td>…22….</td><td>24</td><td>19</td></tr></table> ✓ ✓	2	Mark by row
	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 79.904 award 2 marks --- $\frac{(78.9183361 \times 50.69) + (80.9162896 \times 49.31)}{100}$ **OR** 79.90352697 ✓ = 79.904 (to 3 DP) ✓	2	**ALLOW** value > 3 DP for 1st mark
		(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$ ✓	1	**ALLOW** 4s before 3d, i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 \mathbf{4s^2 3d^{10}} 4p^5$ **ALLOW** upper case D, etc and subscripts, e.g. ……$4S_2 3D_{10}$ **DO NOT ALLOW** [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$ Look carefully at $1s^2 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake

Question			Answer	Marks	Guidance
	(c)	(i)	 Increase from 5–7 (B→N) **AND** 5 below 4 but above 3 ✓ 8(O) below 7 and 9 **AND** above 6 ✓	**2**	**ALLOW** if points correct but straight lines not drawn
		(ii)	Trend described down group *Atomic radius* larger atomic radius **OR** more shells ✓ *Effect of nuclear charge/shielding* Increased nuclear charge is outweighed by increased distance/shielding **OR** **more**/**increased** shielding ✓ *Reactivity **AND** Nuclear attraction*	**3**	***FULL ANNOTATIONS MUST BE USED*** **----------** **ALLOW ORA** but comparison should be used for each mark. **ALLOW** ‘more/higher energy levels’ **ALLOW** ‘electrons further from nucleus’ **ALLOW** ‘different shell’ **OR** ‘new shell’ **IGNORE** more orbitals **OR** more sub-shells **ALLOW more** electron repulsion from inner shells **IGNORE** responses with no comparison e.g. ‘is shielding’ Mark requires statement that reactivity

Question			Answer	Marks	Guidance
			Reactivity increases **AND** less nuclear attraction **OR** less attraction on electrons ✓		increases **AND** reason **IGNORE** nuclear charge/effective nuclear charge **ALLOW** 'less nuclear pull' **OR** 'electrons held less tightly'
			Total	**10**	

Question			Answer	Marks	Guidance
17	(a)*		*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)** All three scientific points are covered in detail and explained thoroughly. *There is a well-developed explanation which is clear and logically structured, with correct labels for the distribution, E_a in distribution linked to areas and benefits clearly linked to energy demand and the environment.* **Level 2 (3–4 marks)** All three scientific points are covered but explanations may be incomplete. **OR** Two of the scientific points are described thoroughly with no omissions. *The explanation has a line of reasoning presented with some structure, and linked to the distribution; attempts to link benefits for energy demand or the environment.* **Level 1 (1–2 marks)** There is a description based on at least two of the main scientific points **OR** One scientific point explained thoroughly with few omissions. *Explanation is communicated in an unstructured way with some links to the Boltzmann distribution or energy demand/the environment.* **0 marks** No response worthy of credit.	6	**Indicative scientific points may include:** **BOLTZMANN DISTRIBUTION**  ***Curve*** • Curve starts at origin (**ALLOW** some leeway) • Curve does not touch the x axis at high energy ***Axes labels*** • y axis: Number of molecules/particles • x axis: Energy (**IGNORE** enthalpy) **ACTIVATION ENERGY** ***Catalyst on distribution*** • Two activation energies labelled • Activation energy with catalyst at lower energy ***Explanation*** • More molecules have more energy than E_a • Greater area under curve above E_a **CATALYST** ***Lower energy demand*** • Reactions take place at lower temperatures ***Environment*** • Reduced CO_2 emissions/burning fossil fuel • Different reactions possible with better atom economy/less waste/less hazardous chemicals (**IGNORE** 'less global warming')
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE**	7	Final answer must be correct and have the correct

Question			Answer	Marks	Guidance
			IF answer = 5184/5180 atm^2 award 7 marks **IF** answer = 5184/5180 with incorrect units award 6 marks		units to score all seven marks
			Equilibrium amounts in mol **2 MARKS** 3 correct ✓✓ 2 correct ✓ $n(H_2O)$ = 0.600 mol $n(H_2)$ = 2.40 mol $n(CO)$ = 0.800 mol		**If there is an alternative answer, check to see if there is any ECF credit possible using working below**
			Partial pressures Total moles = 4.(00) (mol) ✓ $p(CH_4) = \frac{0.200}{4.00} \times 30.0 = 1.50$ atm **AND** $p(H_2O) = \frac{0.600}{4.00} \times 30.0 = 4.50$ atm **AND** $p(H_2) = \frac{2.40}{4.00} \times 30.0 = 18.0$ atm **AND** $p(CO) = \frac{0.800}{4.00} \times 30.0 = 6.00$ atm ✓		**ALLOW ECF** from equilibrium amounts **OR/AND** incorrect total number of moles
			K_p calculation $K_p = \frac{p(H_2)^3 \times p(CO)}{p(CH_4) \times p(H_2O)}$ **OR** $\frac{18.0^3 \times 6.00}{1.50 \times 4.50}$ ✓ K_p = 5184 **OR** 5180 atm^2 ✓ units = atm^2 ✓		Correct values substituted into correct expression for K_p gains first five marks. **ALLOW ECF** with answer 3 or more **SF** up to calculator value, correctly rounded
			Total	**13**	

Question			Answer	Marks	Guidance
18	(a)	(i)	(enthalpy change for) the formation of **1 mole H_2O** from reaction of an acid/H^+ with an alkali/base/OH^- ✓ $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ ✓	2	**ALLOW** (enthalpy change for) the reaction of 1 mol H^+ with 1 mol of OH^- **ALLOW** formation of 1 mol of water from neutralisation If no definition in words, award 1st mark if 1 mol is written under species in the equation, in line with marking criteria **DO NOT ALLOW** formation of 1 mol H_2O from 1 mole of acid and/or 1 mol of alkali **DO NOT ALLOW** formation of 1 mol H_2O from an acid and its conjugate base
		(ii)	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ ✓	1	**IGNORE** state symbols (even if wrong) *not required*
		(iii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer =** –56.43 **OR** –56.4 (kJ mol^{-1}) award 3 marks --- ***Energy change*** energy change = 75.0 × 4.18 × 13.5 = 4232.25 (J) **OR** 4.23225 (kJ) ✓ ***Moles*** n(NaOH) = $1.5(0) \times \frac{50.0}{1000}$ = 0.075(0) (mol) **OR** $n(H_2SO_4)$ = $1.5(0) \times \frac{25.0}{1000}$ = 0.0375(0) (mol) **OR** $n(H_2O)$ formed = 0.075(0) (mol) ✓ $\Delta_{neut}H = -\frac{4.23225}{0.075}$ = –56.43 **OR** –56.4 (kJ mol^{-1}) ✓ – sign **required**	3	**FULL ANNOTATIONS MUST BE USED** --- **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- **IGNORE** any sign shown **ALLOW** 4230 (J) **AND** 4.23 (kJ) up to calculator value correctly rounded **ALLOW ECF** from $\frac{\text{calculated energy change}}{\text{calculated moles } H_2O}$ **ALLOW** 3 significant figures up to calculator value correctly rounded

Question			Answer	Marks	Guidance
	(b)	(i)	$2H_2S(g) + O_2(g) \rightarrow 2S(s) + 2H_2O(g)$ ✓	1	**ALLOW** multiples, e.g. $6H_2S(g) + 3O_2(g) \rightarrow 6S(s) + 6H_2O(g)$
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer =** 3.05×10^7 (g) award 3 marks --- volume of H_2S $= 1.50 \times 10^8 \times 16(0)/100 = 2.4(0) \times 10^7$ dm^3 of H_2S ✓ $n(H_2S)$ (= $n(S)$) $= 2.4(0) \times 10^7/24.0$ mol $= 1(.00) \times 10^6$ mol ✓ Mass S $= 1(.00) \times 10^6 \times 95(.0)/100 \times 32.1$ $= 3.05 \times 10^7$ (g) ✓	3	**ALLOW ECF** from incorrect volume of H_2S **3 SF AND standard form** required
	(c)	(i)	**FIRST, CHECK FOR A VALUE OF ΔG.** **IF** answer = – 89.96(34) (kJ mol^{-1}) award **3 marks** --- **ΔS calculation (2 marks)** $\Delta S = (3 \times 31.8) + (2 \times 188.7) – [(2 \times 205.7) + (248.1)]$ **OR** $\Delta S = 472.8 – 659.5$ ✓ $\Delta S = –186.7$ J mol^{-1} K^{-1} **OR** –0.1867 kJ mol^{-1} K^{-1} ✓ **ΔG calculation (1 mark)** $\Delta G = \Delta H – T\Delta S = –145.6 – (298 \times –0.1867)$ = – 89.96(34) (kJ mol^{-1}) ✓ **Comment (1 mark)** – sign shows the (forward) reaction is feasible ✓ **Temperature at which feasibility changes (1 mark)**	5	**ALLOW** (–) 187 OR 0.187 **ALLOW ECF** from incorrect ΔH **ALLOW** –90 up to calculator value of –89.9634 correctly rounded **ORA** for comment about – sign required for feasibility

Question			Answer	Marks	Guidance
			$T = \frac{\Delta H}{\Delta S} = \frac{-145.6}{-0.1867} = 780$ K **AND** comment that ΔG **OR** $\Delta H - T\Delta S = 0$ ✓		
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer =** –296.8 (kJ mol^{-1}) award 2 marks --- **Correct expression** –145.6 = (2 × –241.8) – (2 × –20.6 + $\Delta_f H(SO_2)$) ✓ **Calculation of $\Delta_f H(SO_2)$ formation** $\Delta_f H(SO_2)$ = (2 × –241.8) – (2 × –20.6) + 145.6 = –**296.8** (kJ mol^{-1}) ✓	**2**	**ALLOW ECF** **ALLOW** 1 mark for (+)296.8 *Subtraction the wrong way around*
			Total	**17**	

Question			Answer	Marks	Guidance
19	(a)	(i)	$(K_a =)\ \frac{[H^+][C_6H_7O_6^-]}{[C_6H_8O_6]}$ ✓ **ALL** species **MUST** have square brackets State symbols **not** required **TAKE CARE** that 'H' is different on top and bottom of expression	1	**ALLOW** $[H_3O^+]$ for $[H^+]$ **IGNORE** state symbols, even if wrong **IGNORE** $\frac{[H^+]^2}{[C_6H_8O_6]}$ **OR** $\frac{[H^+]^2[A^-]}{[HA]}$
		(ii)	$pK_a = -\log K_a = -\log (6.76 \times 10^{-5}) = 4.17$ ✓	1	Answer required to **two DP**
		(iii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer =** 2.82 award 4 marks --- ***n*(vitamin C)** $= \frac{3 \times 0.500}{176}$ $= 8.52(2) \times 10^{-3}$ (mol) ✓ **[vitamin C]** $= 8.52 \times 10^{-3} \times \frac{1000}{250}$ $= 0.0341$ (mol dm^{-3}) ✓ **$[H^+]$** = $\sqrt{(K_a \times [C_6H_8O_6])}$ **OR** $\sqrt{(6.76 \times 10^{-5} \times 0.0341)}$ **OR** 1.52×10^{-3} mol dm^{-3} ✓ **pH** $= -\log(1.52 \times 10^{-3}) = 2.82$ ✓ Answer required to **two DP**	4	**ALLOW ECF** from incorrect *n*(vitamin C) **ALLOW ECF** from incorrect [vitamin C] **must** be derived from $\sqrt{(K_a \times [C_6H_8O_6])}$ **ALLOW ECF** from incorrect $[H^+]$ but **ONLY** if derived from $\sqrt{(K_a \times [C_6H_8O_6])}$
	(b)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF ratio = 0.708** award 3 marks ---	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- ***ANNOTATIONS MUST BE USED*** **ALLOW ALTERNATIVE** using Henderson–

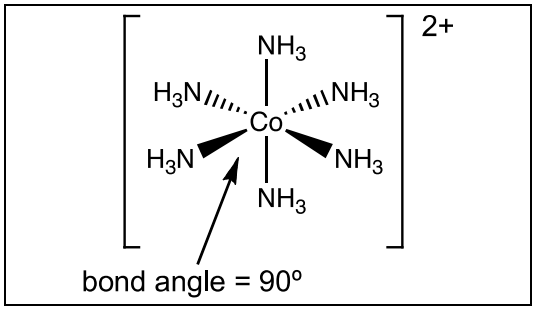
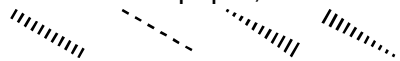
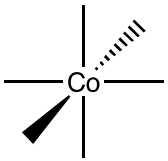
Question			Answer	Marks	Guidance
			$[H^+] = 10^{-pH} = 10^{-4.02} = 9.55 \times 10^{-5}$ (mol dm^{-3}) ✓ $\frac{[C_6H_7O_6^-]}{[C_6H_8O_6]} = \frac{K_a}{[H^+]} = \frac{6.76 \times 10^{-5}}{9.55 \times 10^{-5}}$ ✓ $= \frac{0.708}{1}$ ✓		Hasselbalch equation --- **ALLOW** 9.55×10^{-5} up to calculator value of $9.54992586 \times 10^{-5}$ correctly rounded **ALLOW ECF** from incorrect $[H^+]$ **ALLOW** 0.71 (2 SF) up to calculator value correctly rounded
		(ii)	mass of $C_6H_7O_6Na = 0.708 \times \frac{300}{176} \times 198.0$ = 239 **OR** 240 (mg) ✓	**1**	**ALLOW ECF** from answer to **(i)**
	(c)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer =** 0.0524 (mol dm^{-3}) award 2 marks --- $[H^+(aq)] = 10^{-pH} = 10^{-12.72}$ = 1.91/1.9 x 10^{-13} (mol dm^{-3}) ✓ $[NaOH] / [OH^-(aq)] = \frac{K_w}{[H^+(aq)]} = \frac{1.0 \times 10^{-14}}{1.91 \times 10^{-13}}$ = 0.0524 (mol dm^{-3}) ✓	**2**	**ALLOW** alternative approach via pOH pOH = 14 – 12.72 = 1.28 ✓ $[NaOH] / [OH^-(aq)] = 10^{-pOH}$ = 0.0524 (mol dm^{-3}) ✓ **ALLOW** any value between 0.052 and 0.053 *answer depends on degree of rounding for H^+ but 2 SF minimum* calculator: 0.052480746
			Total	**12**	

Question			Answer	Marks	Guidance
20	(a)		*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)** A comprehensive conclusion which outlines control of concentrations for each experiment with all volumes shown **AND** uses quantitative results for determination of orders and rate equation **AND** calculates a value for the rate constant with units. *There is a well-developed conclusion showing a line of reasoning which is clear and logically structured. The working for control of variables, determination of orders/rate equation and rate constant are clearly linked to the experimental evidence.* **Level 2 (3–4 marks)** Reaches a sound, but not comprehensive, conclusion based on the quantitative results **AND** outlines control of all concentrations, diluting each solution at a time **OR** correctly identifies the orders supported by results and calculates a value for the rate constant. *The conclusion has a line of reasoning with some structure. The working for control of variables **OR** orders/rate equation **AND** rate constant are linked to the experimental evidence.* **Level 1 (1–2 marks)** Attempts to controls concentrations by diluting each solution in turn **AND** reaches a simple conclusion for orders to obtain a rate equation	**6**	**Indicative scientific points may include:** **<u>Control of variables</u>** *Initial concentrations throughout* • mix 10 cm^3 of Br^-, BrO_3^- and H^+ • dilute each solution in turn with water • only one solution changed at a time • total volume kept the same **NOTE:** Volumes of each mixture could be shown and illustrates all points above, e.g. *Expt 1*: 10 / 10 / 10 *Expt 2*: 2.5 + 7.5 H_2O / 10 / 10 *Expt 3*: 10 / 5 + 5 H_2O /10 *Expt 4*: 10 / 5 + 5 H_2O / 5 + 5 H_2O --- **<u>Orders/rate equation</u>** • Br^- 1st order BrO_3^- 1st order H^+ 2nd order **OR** $rate = k[Br^-][BrO_3^-][H^+]^2$ • Supported by reasoning from the experimental results **<u>Calculation of k including units</u>** • Value of k correctly calculated**:** $k = 12$ • Units: $dm^9\ mol^{-3}\ s^{-1}$ **OR** $mol^{-3}\ dm^9\ s^{-1}$

Question			Answer	Marks	Guidance
			with few errors. *The working for orders, and rate equation are linked to the experimental data, but the evidence may not be clearly shown.* **0 marks –** No response or no response worthy of credit.		
	(b)	**(i)**	**3** MnO_4^{2-} + **4** H^+ → **2** MnO_4^- + MnO_2 + **2** H_2O ✓	**1**	**ALLOW** 1 in front of MnO_2
		(ii)	**In acidic conditions** (Concentration of) H^+ increases **AND** equilibrium (position) shifts to the right to reduce concentration of H^+/remove H^+ ✓ **In alkaline conditions** OH^- reacts with H^+ **AND** equilibrium (position) shifts to the left to increase concentration of H^+/add H^+ ✓	**2**	**ALLOW** $H^+ + OH^- \rightarrow H_2O$
	(c)		**In acid:** $H_2(g) \rightarrow 2H^+(aq) + 2e^-$ **AND** $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ ✓ $2H_2 + O_2 \rightarrow 2H_2O$ **AND** Cell potential = 1.23 – 0.00 = 1.23 (V) ✓ **In alkali:** $2OH^-(aq) + H_2(g) \rightarrow 2H_2O(l) + 2e^-$ **AND** $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ ✓ $2H_2 + O_2 \rightarrow 2H_2O$	**4**	**ALLOW** $H_2 + ½O_2 \rightarrow H_2O$

Question			Answer	Marks	Guidance
			AND Cell potential = 0.40 – (–0.83) = 1.23 (V) ✓		**ALLOW** $H_2 + ½O_2 \rightarrow H_2O$
			Total	**13**	

Question			Answer	Marks	Guidance
21	(a)	(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ ✓ Look carefully at $1s^2 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake	1	**ALLOW** $4s^0$ before or after 3d, i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 \mathbf{4s^0 3d^6}$ **DO NOT ALLOW** [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$ **ALLOW** upper case D, etc and subscripts, e.g. ……$3D_{10}$ **IGNORE** an extra $1s^2$ after prompt on answer line
		(ii)	**$FeCl_4^-$** ✓ ↑ Conc HCl(aq) $[Fe(H_2O)_6]^{3+}$ pale yellow solution **KI/I^-** ✓ ↓ ↑ **$(H^+)/MnO_4^-$** ✓ $[Fe(H_2O)_6]^{2+}$ pale green solution ↓ NaOH(aq) **$Fe(OH)_2$ AND green precipitate** ✓	4	Check correct 1– charge **ALLOW** brackets, e.g. $[FeCl_4]^-$ **For I^-,** **ALLOW** SO_2 , (H^+)/Zn **For MnO_4^-,** **ALLOW** H_2O_2 , $(H^+)/Cr_2O_7^{2-}$, Cl_2 **For $Fe(OH)_2$** **ALLOW** $Fe(OH)_2(H_2O)_4$ For colour, **ALLOW** any colour that describes green
	(b)		$n(H_2) = \frac{150}{24000} = 0.00625$ (mol) ✓	4	

Question			Answer	Marks	Guidance
			If **Equation 1**, $M = \frac{0.188}{0.00625} = 30.08$ (g mol^{-1}) ✓ If **Equation 2**, $M = 0.188/0.00625 \times 1.5 = 45.12$ (g mol^{-1}) ✓ Element **M** = scandium/Sc ✓		**DO NOT ALLOW ECF** based on 30 **NOTE:** Only 45 matches Ar values of d-block element/Sc–Zn
	(c)	**(i)**	$[Co(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Co(NH_3)_6]^{2+} + 6H_2O$ ✓ ligand substitution ✓	**2**	 **ALLOW** ligand exchange
		(ii)	 3–D Shape ✓ bond angle 90 º ✓ Bonds **must** be to N of NH_3 ligands	**2**	**IGNORE** charges (**anywhere**) and labels (even if wrong) Square brackets **NOT** required Must contain 2 'out wedges', 2 'in wedges' and 2 lines in plane of paper **OR** 4 lines, 1 'out wedge' and 1 'in wedge': For bond into paper, **ALLOW**:  **ALLOW** following geometry throughout: 
		(iii)	**Empirical formula of complex D**	**4**	

Question			Answer	Marks	Guidance
			Co : N : H : Cl = $\frac{22.03}{58.9} : \frac{31.41}{14.0} : \frac{6.73}{1.00} : \frac{39.83}{35.5}$ **OR** 0.374 : 2.24 : 6.73 : 1.12 ✓ = 1 : 6 : 18 : 3 = $CoN_6H_{18}Cl_3$ ✓ **complex ion C** $[Co(NH_3)_6]^{3+}$ ✓ **complex D** $[Co(NH_3)_6]^{3+}[Cl^-]_3$ ✓		Correct empirical formula subsumes previous mark **ALLOW** $[Co(NH_3)_6]^{3+}$ $3Cl^-$
		(iv)	**Half equations** $[Co(NH_3)_6]^{2+} \rightarrow [Co(NH_3)_6]^{3+} + e^-$ ✓ $H_2O_2 + 2e^- \rightarrow 2OH^-$ ✓ **Overall equation** $2[Co(NH_3)_6]^{2+} + H_2O_2 \rightarrow 2[Co(NH_3)_6]^{3+} + 2OH^-$ ✓	**3**	**ALLOW** multiples throughout **ALLOW** $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$ **ALLOW** $2[Co(NH_3)_6]^{2+} + H_2O_2 + 2H^+ \rightarrow 2[Co(NH_3)_6]^{3+} + 2H_2O$
			Total	**20**	