



GCE

Chemistry B

Unit **H433A/01**: Fundamentals of chemistry

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore
BP	Blank page

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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

Subject-specific Marking Instructions

Treatment of chemical equations:

- Do not allow unnecessary brackets (eg 2(KCl))
- Do not allow wrong element symbols (eg CL)
- Do not allow superscripts for subscripts
- Allow one missing + or arrow if meaning is clear.

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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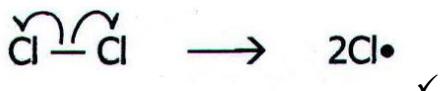
Section A

Q	Key	Mark
1	C	1
2	B	1
3	D	1
4	C	1
5	A	1
6	C	1
7	B	1
8	B	1
9	D	1
10	C	1
11	C	1
12	B	1
13	A	1
14	B	1
15	A	1
16	A	1
17	B	1
18	B	1
19	D	1
20	D	1
21	C	1
22	C	1
23	A	1
24	A	1
25	B	1
26	D	1
27	B	1
28	B	1
29	A	1
30	C	1
		Total 30

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Section B

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Question		Answer	Marks	Guidance
31	(a)	$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^- + \text{H}_2$ ✓ Oxidation state of hydrogen/ H has decreased/goes from +1 to zero. ✓	2	ALLOW $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ ALLOW $\text{H}_2\text{O} + \text{e}^- \rightarrow \frac{1}{2} \text{H}_2 + \text{OH}^-$ ALLOW Water/ H^+ (ions)/ other species shown in (wrong) equation have gained electrons NOT just 'reduction is gain of electrons'
31	(b)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 0.15 award 3 marks If sf incorrect, award 2 marks to anything rounding to 0.15. Moles of NaCl = $2.4 \times 10^5 / 58.5$ OR 4.1026×10^3 ✓ Moles of Cl_2 produced $0.5 \times 2.4 \times 10^5 / 58.5$ OR 2.0513×10^3 ✓ Mass $\text{Cl}_2 = \{0.5 \times 2.4 \times 10^5 / 58.5\} \times 71 = 0.15$ tonnes evaluated to 2sf ✓	3	ALLOW ecf 1. Calculation of moles NaCl 2. Use of ratio $\div 2$ or $\times 0.5$ for a calculated no of moles 3. Moles Cl_2 to mass, unit conversion and 2 sf
31	(c)	Chlorine is toxic AW ✓	1	Incorrect refs to physical state/ flammability are CON IGNORE harmful
31	(d) (i)	 Homolytic ✓	2	Single headed arrows are vital Dots on radicals not essential
31	(d) (ii)	$\text{Cl} + \text{C}_2\text{H}_6 \rightarrow \text{HCl} + \text{C}_2\text{H}_5$ ✓ $\text{C}_2\text{H}_5 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}$ ✓	2	ALLOW $\text{Cl} + \text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{H}$ AND $\text{H} + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}$ for 1 mark DO NOT ALLOW dots on molecules
31	(d) (iii)	$\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2$ AND $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$ ✓ (Homogeneous as) catalyst/it and reagent(s)/ozone are in same/gaseous phase/state ✓ Catalyst is re-generated/reformed/there at beginning and	3	IGNORE dots on radicals IGNORE other equations Third marking point must be related to the idea of the catalyst being recycled.

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Question			Answer	Marks	Guidance
			end/recovered/recycled ✓		
31	(d)	(iv)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = $3.96 \times 10^{-7}\text{m}$ (2 or more sf) award 2 marks</p> <p>Energy (per bond): $302000/6.02 \times 10^{23} = (5.017 \times 10^{-19} \text{ J})$ ✓</p> <p>Use of $E = hc/\lambda$ and calculation, $\lambda = 3.96 \times 10^{-7}\text{m}$ ✓</p>	2	<p>ALLOW any number rounding to $4.0 \times 10^{-7}\text{m}$ with 2 or more sf (to allow for early rounding)</p> <p>$\lambda = 3 \times 10^8 \times 6.63 \times 10^{-34} \times 6.02 \times 10^{23} / 302000$ ALLOW omission/error of one factor (1000, N_A, h or c) for 1 mark. (eg 3.96×10^{-4}, 6.59×10^{-31}, 5.98×10^{26}, 1.32×10^{-15})</p> <p>ALLOW use of $E = h \lambda$ (gives 7.57×10^{14}) for 1 mark</p>
31	(e)		$\text{H}_2\text{SO}_4 + \text{KCl} \rightarrow \text{KHSO}_4 + \text{HCl}$ ✓	1	<p>ALLOW $\text{H}_2\text{SO}_4 + 2\text{KCl} \rightarrow \text{K}_2\text{SO}_4 + 2\text{HCl}$ ALLOW elements in any order in KHSO_4 IGNORE state symbols</p>
31	(f)		<p>I, -1 and 0 ✓ S, +6 and -2 ✓</p> <p>$8\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{H}_2\text{O}$ ✓</p>	3	<p>NOT signs after the numbers. ALLOW ecf on signs after numbers for second point.</p> <p>ALLOW '8H⁺ + 8I⁻' for '8HI' IGNORE state symbols</p>
			Total	19	

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Question		Answer	Marks	Guidance
32	(a)	They are in group 2/ same group/same no of outer electrons/ lose 2 electrons when they react ✓	1	
32	(b)	Magnesium (ions)... are smaller/ have a smaller radius/ have higher charge density ORA ✓ Distort (the charge on) the carbonate (ion)/ polarise the carbonate (ion) more ORA ✓	2	NOT magnesium carbonate/magnesium atoms have a higher charge density. Comparison is essential in both parts.
32	(c)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 647 (2 or more sf) award 3 marks Moles CO ₂ absorbed = 1000/40.3 (= 24.81) ✓ Volume CO ₂ absorbed = ans to 1 st point x 8.31 x 298/95000 (= 0.647) ✓ Evaluation and conversion to dm ³ (x1000) = 647 dm ³ ✓	3	ALLOW ecf throughout ALLOW 2 or more sf 1. Moles of MgO calculated = moles CO ₂ absorbed 2. Correct substitution into $V = nRT/p$ 3. Evaluation and unit conversion

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Question	Answer	Marks	Guidance
32	<p data-bbox="192 201 248 233">(d)*</p> <p data-bbox="344 201 1032 296"><i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i></p> <p data-bbox="344 336 618 368">Level 3 (5–6 marks) Learners are able to explain the origin of colour, electron transitions that cause the lines and the application of the lines to identification of elements. They give most of the points in all 3 sections</p> <p data-bbox="344 536 1021 632"><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p data-bbox="344 671 618 703">Level 2 (3–4 marks) Learners clearly describe points from at least two of the sections or some coverage of all.</p> <p data-bbox="344 807 1021 903"><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p data-bbox="344 943 618 975">Level 1 (1–2 marks) Learners describe points from at least one of the sections or two points in total.</p> <p data-bbox="344 1078 1055 1142"><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p data-bbox="344 1182 461 1214">0 marks No response or no response worthy of credit.</p>	6	<p data-bbox="1218 201 1778 233">Indicative scientific points may include:</p> <p data-bbox="1218 264 1547 296">AO1.1 Origin of colour:</p> <ul data-bbox="1218 328 1704 432" style="list-style-type: none"> <li data-bbox="1218 328 1704 392">• Colour is related to certain visible frequencies/wavelengths of light. <li data-bbox="1218 392 1402 432">• $(\Delta)E = h\nu$ <p data-bbox="1218 472 1603 504">AO1.1 Electron transitions:</p> <ul data-bbox="1218 536 1827 703" style="list-style-type: none"> <li data-bbox="1218 536 1827 600">• Excitation of electrons by absorbing energy (NOT em radiation) <li data-bbox="1218 600 1827 663">• Release of em radiation as electron drops down energy levels. <li data-bbox="1218 663 1738 703">• energy levels are quantised/discrete <p data-bbox="1218 743 1603 775">AO2.1 Use in identification:</p> <ul data-bbox="1218 807 1850 1015" style="list-style-type: none"> <li data-bbox="1218 807 1850 871">• Energy levels and hence gaps are unique to the element. <li data-bbox="1218 871 1850 1015">• Comparison of spectrum showed it did not match any elements known at the time. (Comparison with barium alone only partially matches this criterion). <p data-bbox="1218 1046 1794 1078">ALLOW points made on a labelled diagram.</p>

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Question		Answer				Marks	Guidance
32	(e)	Reagent solution	Ba ²⁺	Pb ²⁺	Fe ²⁺	3	<p>ALLOW 1 mark for each correct row.</p> <p>OR 1 mark for a column of correct observations, as long as 3 reagents used.</p> <p>Cross incorrect boxes and tick remaining columns OR rows to give the higher score.</p> <p>ALLOW anion name instead of full reagent.</p> <p>ALLOW a dash in a box as 'no reaction', but not an empty box.</p> <p>ALLOW white ppt for Ba²⁺ and NaOH</p> <p>ALLOW formulae for names of reagents as long as correct.</p>
		(Dilute) sulfuric acid OR any named soluble sulfate	White ppt	White ppt	Green solution/ no reaction		
		Sodium/potassium hydroxide/ ammonia	Colourless solution/ no reaction	White ppt	(Dirty) green ppt		
		Hydrochloric acid OR any named soluble chloride	Colourless solution/ no reaction	White ppt	Green solution/ no reaction		
		Any named soluble iodide	Colourless solution/ no reaction	Yellow ppt	Green solution/ no reaction		
		Total				15	

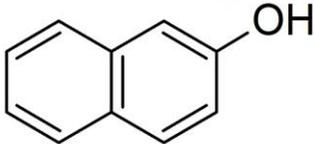
Question		Answer			Marks	Guidance
33	(a)		Increasing temp	Inc pressure	2	ALLOW 1 mark for a correct row if neither column correct. ALLOW up arrows (↑) for increase and down arrows for decrease.
		Effect on yield	Increases/more hydrogen	Decreases/less hydrogen		
		Effect on Kc	increases	No change		
			✓	✓		
	(b)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 0.33 award 2 marks (mark units separately) Calculating eqm concs, CH ₄ = 1.66, H ₂ O = 0.66, CO = 0.34, H ₂ =1.02 ✓ Substitution into correct expression for K _c and calculating, (1.02) ³ x 0.34/1.66 x 0.66 = 0.33 ✓ Units: mol ² dm ⁻⁶ ✓			3	ALLOW ecf from concentrations ALLOW any number rounding to 0.33 1. Amounts at equilibrium 2. Substitution into K _c and evaluation 3. Units Incorrect concentrations substituted into correct K _c expression and correctly evaluated score second mark No ecf from wrong Kc for units.
(c)	(i)	(Entropy increase because) more moles of products/ on right-hand side/more moles produced ✓			1	ALLOW particles/molecule as an alternative to moles NOT just ways of arrangement
(c)	(ii)	FIRST CHECK ANSWER ON ANSWER LINE If answer = +130.6 or any number rounding to +131 award 2 $3S_{H_2} = \Delta_{sys}S + S_{H_2O} + S_{CH_4} - S_{CO}$ OR: $3S_{H_2} = 214.5 + 186.3 + 188.7 - 197.7$ ✓ Evaluation with sign = +130.6/131 ✓			2	No ecf from first point' 130.6/131 without sign scores 1 mark
(d)		$(\Delta_{total}S = +214.5 - 206000/1000) = (+)8.5$ ✓ feasible (since positive)✓			2	ALLOW ecf from negative answer to first mpt and from wrong positive answer Second mark must be consistent with the (implied) sign of the answer to the first point

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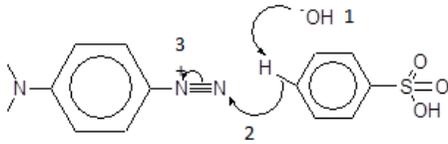
Question		Answer	Marks	Guidance
(e)	(i)	$6 \times 100 / (16 + 18) = 17.6/17.65/18$ ✓	1	ALLOW 2 or more sf
(e)	(ii)	Co-product✓	1	ALLOW 'waste product' DO NOT ALLOW By-product
(f)		Any 2 from:✓ ✓ <ul style="list-style-type: none"> • Stops the release of/ removes toxic/poisonous/dangerous/polluting CO OR no need to transport/remove CO OR uses up/re-uses CO • (Exothermic) reaction provides heat, saving fuel/ heating steam reforming/endothermic reaction • Higher yield of hydrogen/ more hydrogen/higher atom economy/less waste. 	2	Any 2 from: <ol style="list-style-type: none"> 1. relating to utilisation of CO 2. energy considerations 3. yield of hydrogen/ atom economy/ waste <p>NOT 'no waste'/100% atom economy as CO₂ is still a waste product.</p> <p>If more than 2 reasons are given, mark the first 2.</p>
Total			14	

Question			Answer	Marks	Guidance
34	(a)	(i)	<p><i>Bond angles:</i> Both have bond angle of 120° ✓ Both structures have three areas of electron density/ 3 groups (or regions or sets) of electrons/ 3 areas of <u>negative</u> charge (repelling) ✓</p> <p><i>Bond lengths:</i> Structure 1, all bond lengths the same. ✓ Structure 2, C=C shorter than C-C ✓</p>	4	<p>marks for bond angle and explanation. 2nd mark depends on the first</p> <p>1 mark for bond lengths in each structure.</p>
		(ii)	<p>Structure 2 would be expected to have ΔH of 3 x cyclohexene/ $(-360 \text{ (kJmol}^{-1}\text{)})$, ✓ benzene/structure 1 has delocalised (electrons) ✓</p>	2	
	(b)	(i)	<p>(Temp) below 55°C OR 55°C ✓ $\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + 2\text{HSO}_4^- + \text{H}_3\text{O}^+$ ✓</p>	2	<p>IGNORE any reagents mentioned or conditions other than temperature for the first point ALLOW $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{HSO}_4^- + \text{H}_2\text{O}$ ALLOW $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$ then $\text{H}_2\text{NO}_3 \rightarrow \text{NO}_2^+ + \text{H}_2\text{O}$</p>
		(ii)	<p>NaNO_2/ Sodium nitrate(III)/ sodium nitrite AND HCl ✓ Temp below 5°C ✓</p>  <p>Alkaline conditions AW ✓</p>	4	<p>ALLOW HNO_2/name ALLOW ice cold</p> <p>ALLOW H drawn on coupling carbon</p> <p>ALLOW third mark if appropriate conditions shown in middle box IGNORE any other reagents in bottom box unless CON</p>
	(c)		(Sodium) Sulfonate	1	IGNORE any oxidation state given

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Question		Answer	Marks	Guidance
	(d)	✓ ✓ ✓ 1 for each arrow 	3	ALLOW arrows that, if continued in the same direction, would start and finish in the correct places, (anywhere on appropriate atom or bond). ALLOW arrow from H into the ring AND an arrow from the ring to the right-hand N as alternative for arrow 2
	(g) (e)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 0.8(0) award 2 marks $[H^+] = 10^{-3.7}$ evaluated = 2.0×10^{-4} ✓ $K_a / [H^+] = [In^-] / [HIn]$ evaluated = 0.80 ✓	2	Must have 'H ⁺ =' to score the first point ALLOW 1: 1.25, 4: 5 etc NOT 1: 0.8
Total			18	

Question		Answer	Marks	Guidance								
35	(a) *	<p>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks)</p> <p>Gives a clear account with at least 1 fine detail point in all 3 sections.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks)</p> <p>Gives a point from each of the 3 sections. OR Gives an account of 2 areas, both including a fine detail point.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks)</p> <p>Makes at least 2 relevant points.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>	6	<p>Indicative scientific points might include: AO3.2 Make judgements – Interpret practical procedure</p> <p>1 Use of ppt</p> <ul style="list-style-type: none"> • Weigh ppt <p>Fine detail:</p> <ul style="list-style-type: none"> • Filter to collect ppt • Rinse ppt with distilled/deionised water • Dry precipitate. This may be in the remedies for inaccuracy <p>2 Use of mass of ppt to find x</p> <ul style="list-style-type: none"> • Find moles of $MgCO_3$ <p>Fine detail:</p> <ul style="list-style-type: none"> • Appreciation that mass ppt related to moles $MgSO_4$ • Subtract mass of $MgSO_4$ from original mass of crystals to find mass of water <ul style="list-style-type: none"> • calculate no. moles water and find the ratio. <p>3 AO3.4 Develop and refine At least one point from:</p> <table border="1"> <thead> <tr> <th>Inaccuracy</th> <th>Remedy (fine detail)</th> </tr> </thead> <tbody> <tr> <td>Not enough sodium carbonate added to precipitate all the magnesium ions or not all $MgSO_4$ dissolved</td> <td>Add excess sodium carbonate Add more water</td> </tr> <tr> <td>Mass of ppt inaccurate due to water</td> <td>dry ppt IGNORE means of drying</td> </tr> <tr> <td>Losses of substances when filtering/pouring etc</td> <td>Rinse all containers with distilled water and add to the filter.</td> </tr> </tbody> </table>	Inaccuracy	Remedy (fine detail)	Not enough sodium carbonate added to precipitate all the magnesium ions or not all $MgSO_4$ dissolved	Add excess sodium carbonate Add more water	Mass of ppt inaccurate due to water	dry ppt IGNORE means of drying	Losses of substances when filtering/pouring etc	Rinse all containers with distilled water and add to the filter.
Inaccuracy	Remedy (fine detail)											
Not enough sodium carbonate added to precipitate all the magnesium ions or not all $MgSO_4$ dissolved	Add excess sodium carbonate Add more water											
Mass of ppt inaccurate due to water	dry ppt IGNORE means of drying											
Losses of substances when filtering/pouring etc	Rinse all containers with distilled water and add to the filter.											

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Question	Answer	Marks	Guidance
(b)	<p>FIRST CHECK ANSWER ON ANSWER LINE If answer = -99.9 or -100 award 4 marks (+) 99.9 or -68.1 scores 3 (1 of the last 2)</p> <p>1. Use of $Q=mc\Delta T$: $50 \times 3.0 \times 4.18$ (= 627 J or 0.627 kJ) ✓</p> <p>2. moles $\text{MgSO}_4 \cdot 7\text{H}_2\text{O} = 9.7 / 246.4 = 0.0394$ AND Scale up for 1 mole: $\Delta H = 0.627 / 0.0394$ = (+)15.9 kJ mol⁻¹ ✓</p> <p>3. $\Delta H = (-84.0 - (+15.9))$ ✓ OR Cycle (or enthalpy level diagram) labelled with species ✓</p> <div style="text-align: center;"> <pre> graph TD A["MgSO4(s) + 7H2O(l)"] --> B["MgSO4(aq)"] C["MgSO4·7H2O(s)"] --> B style A fill:#fff,stroke:#000 style B fill:#fff,stroke:#000 style C fill:#fff,stroke:#000 </pre> </div> <p>4. Evaluated with sign = -99.9 kJ mol⁻¹ ✓</p>		<p>ALLOW ecf throughout.</p> <p>IGNORE sign for first point. A common mistake is to take the mass as 59.7.</p> <p>NOT -15.9 as temp of water falls.</p> <p>IGNORE (7)H₂O in bottom box.</p>
(c)	<p>Top box: $\text{Mg}^{2+}(\text{g})$ AND $\text{SO}_4^{2-}(\text{g})$ ✓</p> <p>$\Delta_{\text{LE}}H$ (= -1922 -1099 +84) = -2937 ✓</p>	2	
(d)	<p>Strontium (ions) are larger/have a lower charge density ✓</p> <p>so forces between water and strontium/ion-dipole forces less strong OR fewer water molecules surround it OR Not enough energy released in making ion-dipole bonds OR $\Delta_{\text{hyd}}H$ is less exothermic/releases less energy ✓</p>	2	<p>1 Charge density/radius.</p> <p>2 Correct statement on the interactions between strontium ions and water.</p> <p>IGNORE smaller/larger in relation to $\Delta_{\text{hyd}}H$. ORA throughout</p>
	Total	14	

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