Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			**B**	1	**<u>Examiner's Comments</u>** Some candidates correctly chose $MgSO_4$. No option showed up as a 'main' distractor and many candidates may have just guessed. As this question assesses recall of a specification learning outcome, this suggests that the content had not been learnt by many candidates. Note also the points made in Question 6 about underlining the word 'not'.
			Total	**1**	
2			$2\ Ba + O_2 \rightarrow 2\ BaO$ ✓ $BaO + H_2O \rightarrow Ba(OH)_2$ ✓ Neutralisation **OR** acid-base ✓	3	**ALLOW** multiples **IGNORE** state symbols, even if incorrect **ALLOW** $Ba + H_2O \rightarrow BaO + H_2$ (reaction with steam) **ALLOW** other correct equations e.g. with less reactive metal oxide **<u>Examiner's Comments</u>** Some candidates coped well with this question which was based on the AS part of the specification and gained all three marks. Common errors were for unbalanced equations in reaction 1 or adding H_2 to the product of reaction 2. Reaction 3 was often, incorrectly, considered as: redox, halogenation, nucleophilic substitution or a precipitation reaction **Assessment for learning**

					OCR support We have produced a topic exploration pack to assist with learning about the reaction of group 2 elements and their compounds: [Teach Cambridge (ocr.org.uk)]
			Total	**3**	
3			**B**	1	**Examiner's Comments** The correct answer was B. Most candidates selected this response and understood that hydroxides were needed to neutralise an acid. Incorrect options were also selected in equal measure. It is important that candidates make the link between theory and practical use.
			Total	**1**	
4	a	i	Be: $1s^22s^2$ F: $1s^22s^22p^5$ ✓ Mg: $1s^22s^22p^63s^2$ C*l*: $1s^22s^22p^63s^23p^5$ ✓ Block: s p ✓	3	**1 mark** per correct row **ALLOW** upper case letter S and P, and subscripts, e.g. $2S_22P_5$ **IGNORE** superscripts/numbers given on block (e.g. s^2 and p^5) if the letter is clear **Examiner's Comments** A very well answered question with most candidates very confident in giving the correct electron configurations and blocks. Errors were rare but included: $2p^5$ or $3p^6$ ending for Cl; using mass number for number of electrons; and assigning group 17 as d block and giving orbital box diagrams rather than block.
		ii	Across period 2, the (2)s subshell fills first, followed by the (2)p ✓ **same pattern or trend** of filling (the subshells) repeated in other periods ✓	2	**ALLOW** Elements in the same group have same number of electrons in their outer shells or subshell e.g. s^2 in group 2/ s^2p^5 in group 17(7) **ALLOW** Elements in the same period have the same number of energy levels/shells

					ALLOW for both marks for indication that the pattern repeats across each period e.g Across each period, elements repeat the pattern of electrons filling the s-subshell then p-subshell ✓ ✓ **Examiner's Comments** Many found this question challenging despite doing well in Question 2(a)(i). The question states 'use your answers from (a)(i)' but not many candidates wrote about the electron configurations they had given. Many gave very simplistic responses in terms of the number of electrons increasing but made no reference to how those electrons are arranged (e.g. 'number of electrons increases across a period as the electron configuration gets higher' or 'atomic number increases'). Some candidates struggled with terminology, often referring to 'block' or 'orbital' instead of subshell (e.g. 'outer electrons are in same block', 'going across a period the number of orbitals increases', 'elements in same group have their highest energy electron in same block' or 'orbital'). Candidates need clarity on the terminology used for electron configurations and periodic table i.e. blocks, shells, sub-shells and orbitals. It was rare for candidates to score both marks as this was a question that they were unfamiliar with. However, some did gain a mark for linking the number of outer shell electrons to the group number or stating that elements in the same period have the same number of shells. It was not enough to refer to the highest energy electron being in the s-subshell or p-subshell as this is the link to the block, but all groups in same block will be the same. Some described the trend in other physical or chemical properties. Some

					examples included: 'Elements have same chemical and physical properties due to similar electronic configuration'; 'as you go across period, number of electrons increase and their boiling and melting points increase'; and 'electrons are more easily lost in a paired orbital, due to greater repulsion and so have lower ionisation energies'. **OCR support** We have produced a transition guide on the topic of atomic structure. It covers content from KS4 and how this is developed at KS5 with a wide range of suggested resources to support teaching. At KS4, candidates are expected to be able to explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms, with development at KS5 to arrangement in to s, p and d orbitals. https:/ocr.org.uk/Images/170375-atomic-structure-ks4-ks5.pdf
		iii	Mg loses (2) electrons **AND** Cl gains an electron ✓ To gain a full/complete shell **OR** Noble gas configuration **OR** Stable/full octet✓	2	**ALLOW** Mg is oxidised **AND** Cl is reduced **<u>Examiner's Comments</u>** Generally, this question was well answered with a clear understanding of how and why ions are formed. However, approximately a quarter of students only gained 1 mark as they either didn't explain electrons being lost by Mg and gained by Cl or gave no justification. A common slip was stating Cl has one electron in its outer shell. Some described bonding between Mg and Cl, which wasn't what the question asked, but this didn't prevent them from scoring both marks.

		iv	$2Mg + O_2 \rightarrow 2MgO$ ✓	1	**ALLOW** multiples e.g. $Mg + \frac{1}{2}O_2 \rightarrow MgO$ **IGNORE** state symbols even if wrong **Examiner's Comments** Many candidates correctly gave the balanced equation here. However, some didn't balance but had the correct formula. A few gave Mg_2 as a reactant or MgO_2 as a product. Some had O_2 on both sides of the equation.
	b	i	Ca loses **2** electrons **AND** Oxidised✓ H gains 1 electron (per atom) **AND** Reduced✓	2	**ALLOW** H gains an electron **OR** gains electrons **OR** gains 2 electrons **ALLOW** 1 mark for Ca is oxidised **AND** H is reduced **ALLOW** 1 mark for Ca loses electron(s) **AND** H gains electron(s) **IGNORE** oxidation numbers even if incorrect **Examiner's Comments** Explaining redox reactions is a common question in exam papers, however here candidates needed to do it 'in terms of electron transfer'. Subsequently, many lost a mark as they identified oxidation and reduction in terms of oxidation numbers only. However, many gave responses both in terms of oxidation numbers and electrons. It was necessary to be specific here and say Ca had lost 2 electrons, so a few lost the mark by only referring to 'Ca losing electrons'. Some lost marks for only describing oxidation of Ca and not reduction of H. There was some evidence that candidates were not sure of Cl's role in the reaction (i.e. as a spectator ion) with some stating it was reduced

					and/or accepted electrons from Ca but then gave them to H.
		ii	*n*(HCl) = 0.012 (mol)✓ *n*(Ca) required to react with HCl = 0.006 (mol) **OR** 0.0100 mol Ca would need 0.02 mol HCl to completely react ✓ Ca reacts with water ✓	3	Second mark must show recognition of the 2:1 ratio e.g. **ALLOW** ratio is 1:2 but here only 1:1.2 so Ca is in excess **<u>Examiner's Comments</u>** Most candidates correctly calculated the amount of HCl as 0.012 mol. However, many struggled with demonstrating that Ca is in excess. Responses often highlighted misconceptions here in terms of candidates' understanding about excess and limiting reagents. For example, 'Ca has a lower concentration than HCl so becomes the limiting reagent' and 'Not all the HCl had reacted' Many compared moles of HCl calculated (i.e. 0.012) directly to moles of Ca (i.e. 0.01) saying that HCl was in excess, despite being told otherwise in the question. Some had the 2:1 ratio of HCl to Ca the wrong way around. Some attempted to calculate mass of Ca and HCl to use for comparison. Only a small proportion of candidates were able to access the third mark and correctly suggest that Ca was also reacting with water. Some other suggestions that were seen included: • 'Ca reacted with oxygen or was impure'. In both cases this would mean that we would expect solid to remain • 'Higher concentration of HCl added', or 'HCl is a strong acid', or 'acid acts as a catalyst'. • 'H_2 evolved' or 'Ca reacts with hydrogen formed'.

					• 'Human error', 'didn't weigh Ca correctly', 'measured volume of HCl incorrectly'. **Misconception** Candidates often struggle to understand the concepts around limiting reagents and those in excess. Using a simple baking analogy can help to relate this to everyday life. For example: To make 10 pancakes you need 100 g flour, 2 eggs and 300 ml milk How many pancakes can I make if I have only 50 g flour, 2 eggs and 300 ml milk? Which is the limiting ingredient and which are in excess? The number of pancakes we can make is the theoretical yield.
			Total	**13**	
5		i	$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ✓	1 (AO 2.6)	**ALLOW** multiples **ALLOW** Mg^{+2} **IGNORE** state symbols **<u>Examiner's Comments</u>** Ionic equations still present candidates with a challenge. A few candidates scored the mark but many candidates gave a full equation or one that contained a mismatch of spectator ions as well as the correct ions.
		ii	HC*l* is a strong acid/completely dissociates **AND** CH_3COOH is a weak acid/partially dissociates ✓ Greater H^+ concentration in HC*l* **AND** More frequent collisions / faster rate	3 (AO 1.1 × 1) (AO 3.1 × 2)	**IGNORE** HCl is a strong**<u>er</u>** acid than ethanoic acid. **ALLOW** ORA

			of reaction ✓ More CH_3COOH dissociates until same number of moles of H^+ released **OR** same total moles H^+ produced (by the end) **OR** (Both acids are monobasic) and have the same number of moles of acid ✓		**DO NOT ALLOW** dibasic/tribasic **Examiner's Comments** This question proved challenging for the candidates to identify the three ideas: Those of comparing acids, comparing moles and comparing rates. Very few candidates were able to score the 3 marks. Most candidates recognised the different strength of the two acids, but some only used comparative language. Some linked the moles of acid used to the volume of gas produced but many simply restated the same volume and concentration which is given within the question. Only a few candidates linked the higher initial $[H^+]$ in HCl to the increased rate through more frequent collisions. A common issue was describing the rate of dissociation rather than the $[H^+]$ present in determining the rate of the reactions or mentioning that it dissociates more but not linking this to the H+ concentration.
			Total	**4**	
6			**Ist IE of Mg and Sr** (Mg) removes electron from shell closer to the nucleus / smaller **atomic** radius ✓✓ Greater nuclear **attraction** (between atom and outer electron) ✓ **2nd/1st IE of Sr** 2nd electron removed from cation/positively charged **ion** **OR** proton:electron ratio (in (1)+ ion) is great**er** (than in atom) ✓	4 (AO 1.1) (AO 1.2) (AO 1.1) (AO 1.2)	**ORA** throughout **ALLOW** going down the group for comparison of Mg/Sr Assume 'it' means Mg **ALLOW** (Mg) fewer shells **ALLOW** less shielding **ALLOW** removal of electron from 3s rather than 5s **ALLOW** Greater attraction between nucleus (and outer electron) **ALLOW** Sr^+ **ion** smaller (than Sr atom)

			Greater nuclear **attraction** / **attraction** between ion (and outer electron)✓		**ALLOW same** number of protons/nuclear charge **attracting** one fewer electron **IGNORE** repulsion between electrons in the s orbital **IGNORE** shielding **Examiner's Comments** Most candidates were able to explain why the first ionisation energy of Mg is greater than that of Sr due to the Mg's smaller atomic radius/less shielding and therefore increased nuclear attraction. Candidates should be reminded that there is no requirement to restate the question in their answers. Terminology is important and some candidates lost marks as they referred to nuclear radius instead of atomic radius. However, most candidates did not recognise that the second ionisation energy of Sr involves removing an electron from a +1 ion and instead discussed the repulsion between electrons in the s orbital. Atomic radius instead of ionic radius was often seen when discussing the Sr^+ ion. Some candidates were still referring to Mg in this part of their answer and they should be advised to reread the question between each part to remain focused on the requirement.
			Total	**4**	
7		i	**Equation** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ All formulae and balancing correct ✓ **Observation** Effervescence/fizzing/bubbles **OR** Ca/solid disappears/dissolves **OR** Forms a white ppt/solid ✓	2 (AO 2.6) (AO 1.2)	**ALLOW** correct multiples including fractions **IGNORE** state symbols, even if wrong **IGNORE** temperature change, pH change or gas formed i.e. must be an observable change. **IGNORE** turns cloudy **DO NOT ALLOW** Colour change **Examiner's Comments**

					Most candidates scored the mark for the correct observation. A few said what would happen rather than what they would see, e.g. gas is formed, pH would increase, mass lost or even reference to the ‘squeaky pop’ test. Many struggled to give the correct balanced equation with either CaO being given as a product or incorrect balancing. Many did not have a gas produced but then had bubbling as an observation. **OCR support** OCR has some resources to help support the understanding of balancing symbol equations such as this delivery guide for Atoms and equations.
		ii	More vigorous effervescence/fizzing/bubbling **OR** Ba/solid disappears/dissolves faster **OR** White ppt formed less rapidly ✓	1 (AO1.2)	**ORA** if clearly references Ca **ALLOW** AW such as stronger/ rapid/ quicker/ more quickly/ more violent **ALLOW** less or no ppt (as barium hydroxide is more soluble) **Note**: Must reference observation not just reaction e.g. more vigorous reaction. **IGNORE** finishes first **IGNORE** more bubbles (need idea of rate) **IGNORE** exothermic **Examiner’s Comments** Responses not about observations were very common, e.g. more vigorous reaction, Ba is more reactive. Some described Ba as being less reactive. Many responses did not include the idea of rate (for example, ‘more bubbles’) or were not comparative (for example, ‘vigorous bubbling’).

			Total	**3**	
8	a	i	Ca fizzes faster **AND** Ca dissolves/disappears more quickly ✓	1 (AO2.3)	**CARE** Both needed for **1 mark**. **ORA ALLOW AW** **IGNORE** finishes first **IGNORE** more bubbles (need idea of rate) **IGNORE** exothermic **Examiner's Comments** Very few candidates made two valid statements where both clearly indicated an idea of relative rate – in almost all cases one of the descriptions would be about quantity of gas rather than rate of gas production. Some candidates identified a precipitate being formed, colour change, or gave a general answer of the reaction happening quicker.
		ii	Oxidation $Mg \rightarrow Mg^{2+} + 2e^-$ ✓ Reduction $2H^+ + 2e^- \rightarrow H_2$ **OR** $H^+ + e^- \rightarrow ½H_2$ ✓	2 (AO2.6×2)	In half equations, **ALLOW** the use of e for e^- **ALLOW** $Mg - 2e^- \rightarrow Mg^{2+}$ **IGNORE** state symbols even is wrong BUT half equations **MUST** only have species that change. For charges on half equations, **ALLOW** Mg^{+2} for Mg^{2+} **OR** H^{+1} for H^+ If **BOTH** half equations are correct but shown with oxidation and reduction the wrong way around, award 1 mark from the 2 marks for half equations **Examiner's Comments** Some candidates coped well with this question which was based on the AS part of the specification and gained both marks. More candidates gained

					1 mark through writing one half equation, usually the oxidation of magnesium. Common errors were for chlorine to featuring in the reduction half equation and the lack of electrons in their answers. Very few candidates mixed up the oxidation and reduction equations.
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.53(g) award 5 marks** **---** **[H^+]** = $10^{-13.12}$ **OR** 7.58..... × 10^{-14} (mol dm^{-3}) ✓ $[OH^-] = \frac{1 \times 10^{-14}}{7.58........ \times 10^{-14}}$ **OR** 0.1318 .... (mol dm^{-3}) ✓ $n(OH^-)$ in 250 cm^3 = $\frac{0.1318.....}{4}$ **OR** 0.0329...... (mol) ✓ $n(Ba(OH)_2)$ or $n(BaO)$ = $\frac{0.0329.......}{2}$ **OR** 0.0164….. (mol) ✓ **Mass of BaO** = 0.0164..... × 153.3 = 2.53 (g) **3SF** ✓	5 (AO2.4×5)	**ALLOW ECF and 3SF throughout.** **ALLOW** calculation process in any order. **IGNORE** rounding errors past **3SF** **---** Calculator: 7.58577575 × 10^{-14} Calculator: 0.1318256739 **ALLOW** alternative approach using pOH for first 2 marks. p[OH^-] = 14 − 13.12 = 0.88 [OH^-] = $10^{-0.88}$ = 0.1318….. Calculator: 0.03295641846 0.033(0) comes from [OH^-] = 0.132 Calculator: 0.01647820923 Calculator: 2.526109475 **Common errors 4 marks** 5.05g Not dividing by 2 2.82g Use of M_r for $Ba(OH)_2$ 5.06g rounds to 0.132 in M2 then not dividing by 2 **3 marks** 5.65g not dividing by 2 and using Mr for $Ba(OH)_2$ **<u>Examiner's Comments</u>** Although few candidates got the correct final answer, however almost all achieved some marks from this calculation through error carried

					forward, with marks spread across the available range. Almost all candidates were able to find the concentrations of hydrogen and hence hydroxide ions. A few candidates successfully used $p[OH^-]$ method. Most were able to calculate the moles of hydroxide ions in $250cm^3$. Many then did not realise the need to half this number to find the moles of barium, and/or used the Mr for barium hydroxide instead of barium oxide.
		ii	$Ba^{2+}(aq) + 2H^+(aq) + SO_4^{2-}(aq) + 2OH^-(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$ ✓	1 (AO3.2)	**ALLOW** multiples **ALLOW** $H^+(aq) + OH^-(aq) \rightarrow H2O(l)$ **OR** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **<u>Examiner's Comments</u>** This question was answered well, with many candidates giving one of the equations in the 'ALLOW' part of the mark scheme. Those candidates who did not gain this mark gave full equations or missed out state symbols.
			Total	**9**	
9	a	i	Any value in range: 8–14 ✓	1 (AO1.1)	**<u>Examiner's Comments</u>** Most candidates gained this mark. The most common incorrect response was pH 7 with a few giving a pH value of less than 7.
		ii	White precipitate/white solid ✓ $BaSO_4$ ✓	2 (AO 3.1) (AO 3.2)	**<u>Examiner's Comments</u>** Most candidates were able to give the formula of the barium compound as $BaSO_4$. However, they did not recognise that this would cause a white ppt to be seen, presumably as not in the context of qualitative ions testing. Many candidates said they would see bubbling/fizzing. Some gave a colour change as they were possibly considering what would be seen if an indicator is present. Others

					mentioned a precipitate but with no colour given. Some candidates gave the incorrect formula, such as Ba_2SO_4 or $Ba(SO_4)_2$, again showing the importance of practising writing formulae. In addition, some candidates wrote out the whole equation for the reaction. **OCR support** We have produced a topic support pack to assist with learning about the reaction of group 2 elements and their compounds: http:/www.ocr.org.uk/Images/364103-chemistry-of-group2.docx
	b	i	$Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$ All formulae and balancing correct ✓	1 (AO2.6)	**IGNORE STATE SYMBOLS** **ALLOW** multiples **IGNORE** state symbols (even if wrong) **<u>Examiner's Comments</u>** Around half of all candidates did not score this mark. The most common error was giving SrO as the product rather than the hydroxide. Other errors included incorrect balancing (missing 2 on H_2O, SrOH as the formula of the hydroxide and no hydrogen formed (often giving H_2O instead)). **Assessment for learning** Regular practice writing formulae and balancing chemical equations will help to consolidate these concepts, avoiding basic errors such as giving formula of group 2 hydroxide as SrOH.

		ii	**Oxidation** Sr from **0** to **+2** ✓ **Reduction** H from **+1** to **0** ✓	2 (AO 2.1 × 2)	**ALLOW** 2+ for +2 and 1+ for +1 '+' is required in +2 and +1 oxidation numbers **ALLOW** H_2 for hydrogen **ALLOW** 1 mark for elements **AND** all oxidation numbers correct but oxidation and reduction wrong way round **OR** not given. **IGNORE** numbers around equation in **(i)** *(treat as rough working)* **Examiner's Comments** Most candidates managed to score at least 1 mark for this question. The most common reason for losing a mark, despite demonstrating a good understanding of redox, was stating that H changed from +2 to 0 (need to give oxidation number per atom). Other errors seen included only giving change for Sr, descriptions in terms of electrons rather than oxidation numbers, Sr change from 0 to +1 (linked to SrOH), oxygen being reduced rather than H and mixing up oxidation/reduction or not specifying.
		iii	*Atomic radius* Ca has smaller atomic radius **OR** fewer shells ✓ *Effect of nuclear charge/shielding* Ca has **less/decreased** shielding ✓ *Nuclear attraction* Ca has greater nuclear attraction (for electrons) **OR** Ca has a higher ionisation energy	3 (AO 1.2) (AO 1.2) (AO 1.2)	**FULL ANNOTATIONS MUST BE USED** -- **ORA in terms of Sr** **Comparison** needed for each mark. **ALLOW** 'fewer energy levels' **ALLOW** 'electrons closer to nucleus' **IGNORE** fewer orbitals **OR** fewer sub-shells **OR** different shell **ALLOW more** electron repulsion from inner shells

			OR more energy is required to lose the outer electrons✓		**IGNORE** nuclear charge/effective nuclear charge **ALLOW** 'less nuclear pull' **OR** 'electrons held less tightly' **Examiner's Comments** Most candidates gained some marks here although a significant proportion were unable to score all 3 marks covering atomic radius, shielding, nuclear attraction/IE. The mark most often missed was for shielding. Some candidates did not answer the question asked and gave the trend down the group so could not be given marks unless they made it clear Sr is below Ca in the group. Care must be taken to answer question asked not similar questions they have seen before. The best responses were those with direct comparative statements, e.g. "Ca has a smaller atomic radius than Sr". It is worth noting that harder/easier to lose electrons didn't gain marks, but was seen fairly frequently, as response needs to be in terms of energy required or linked to nuclear attraction.
			Total	9	