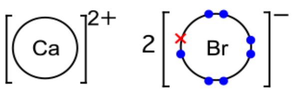
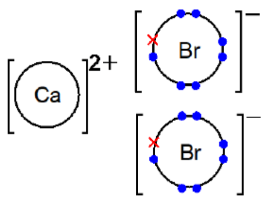
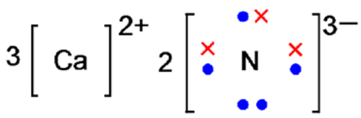
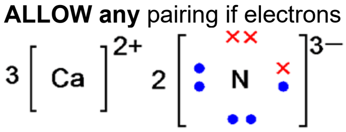
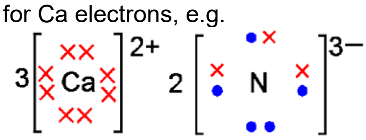
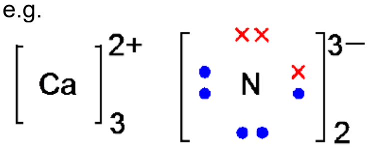
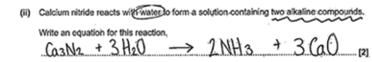
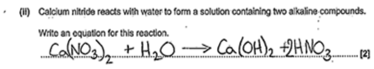
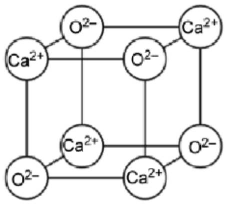
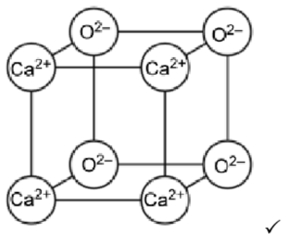
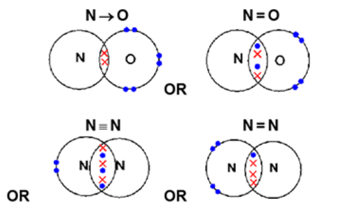
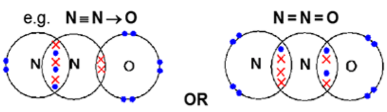
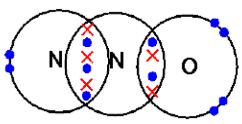
Mark scheme – Group 2

Question			Answer/Indicative content	Marks	Guidance
1			**Equation**: Mg + $2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$ ✓ **Oxidation**: Mg from 0 to +2 ✓ **Reduction**: H from +1 to 0 ✓	3 (AO 2.6) (AO 1.2) (AO 1.2)	**ALLOW** $Mg(CH_3COO)_2$ **ALLOW** multiples **IGNORE** Oxidation numbers in formulae **IGNORE** state symbols Mark independently from equation **ALLOW** 1 mark for correct oxidation numbers but incorrectly linked to redox.
			Total	**3**	
2		i	 Ca shown with either 8 or 0 electrons **AND** Br shown with 8 electrons with 7 crosses and 1 dot (or vice versa) ✓ Correct charges on both ions ✓	2 (AO1.2×1) (AO2.5×1)	**ALLOW** separate Br– ions, i.e.  For first mark, if eight electrons are shown around Ca, the 'extra' electrons around Br must match the symbol chosen for the electrons for Na. **IGNORE** inner shells Circles or brackets not required **<u>Examiner's Comments</u>** Most candidates were able to give the correct diagrams for ionic bonding, although care needs to be taken that diagrams are well drawn with both charges given. Some gave diagrams for covalent bonding.
		ii	**Atomic radius** Ba has a **greater** atomic radius than Ca **OR** Ba has **more** shells **OR** Ba has **more** shielding ✓ **Attraction** Nuclear attraction is less in Ba **OR** (outer) electrons in Ba are less attracted (to nucleus) **OR** Increased distance / shielding in Ba outweighs increased nuclear charge ✓	3 (AO1.1×1) (AO2.3×2)	Comparison required throughout **ORA** throughout For **more** shells, **ALLOW** higher energy level **IGNORE** more orbitals **OR** more sub-shells **IGNORE** 'different shell' or 'new shell' **ALLOW** Ba has less nuclear pull' **OR** 'Ba electrons are less tightly held' **IGNORE** less effective nuclear charge' **IGNORE** 'nuclear charge' for 'nuclear attraction' **ALLOW** easier to oxidise Ba

			Ionisation energy Ionisation energy of Ba is less **OR** (outer) electrons in Ba are less attracted (to nucleus) **OR** easier to remove (outer) electrons in Ba ✓		**<u>Examiner's Comments</u>** It was important to answer the question asked. A number of responses lost marks for describing the general trend down group 2 without making reference at all to calcium and barium. Most candidates managed to score at least one mark here but a considerable proportion missed the second marking point explaining that nuclear attraction was less in Ba.
			Total	**5**	
3			**Route 1** *Reactant:* Add water (to Ba) **OR** H_2O in equation ✓ *Balanced equation:* $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓ **Route 2** *Balanced equation with O_2* $2Ba + O_2 \rightarrow 2BaO$ ✓ *Balanced equation with H_2O* $BaO + H_2O \rightarrow Ba(OH)_2$ ✓	4 (AO3.3) (AO2.6) (AO3.3) (AO3.3)	**ALLOW** multiples in equations Balanced equation automatically collects 2 marks for Route 1 **ALLOW** 1 mark for **BOTH** reactants in route 2: i.e. React with O_2 **AND** then with H_2O **NOTE** 3 correct balanced equations → 4 marks **<u>Examiner's Comments</u>** Many candidates were able to calculate the amount of HNO_3 in the titration as 4.28×10^{-3} mol. Most candidates were credited for the amount of $Ba(OH)_2$ as 2.14×10^{-3} mol, half the calculated amount of HNO_3. Candidates then need to scale up this value by 1000/25 to obtain the concentration as 0.0856 mol dm^{-3}. All intermediate calculations gave values to 3 significant figures. Discrimination was extremely good, but about a third of candidates did not receive any marks. Candidates should be encouraged to practise stock titration calculations as part of their preparation for the examinations. Candidates should show clear working so that credit can be given for such responses by applying error carried forward. Many candidates produced largely unreferenced numbers.
			Total	**4**	
4		i	$Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$ ✓	1(AO2.6)	**ALLOW** correct multiples including fractions **IGNORE** state symbols

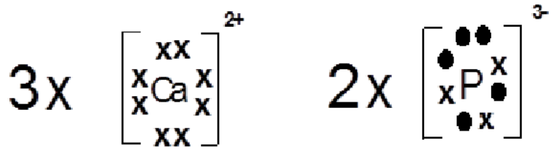
					Examiner's Comments Nearly half of the candidates did not answer this question correctly, mainly because of incorrect balancing or the formation of strontium oxide instead of strontium hydroxide.
		ii	Two points (✓✓) from With calcium: **1.** less vigorous fizzing/bubbling/effervescence **2.** dissolves more slowly/slower reaction **3.** solution has a lower pH/less alkaline **4.** precipitate forms/less soluble	2(AO2.3×2)	**IGNORE** gives out less/more heat, less reactive, less gas **Examiner's Comments** Most candidates were able to identify at least one difference, although a significant number of responses stated the opposite trend
			Total	**3**	
5		i	$CaO + H_2O \rightarrow Ca(OH)_2$ ✓	1 (AO 2.8)	**ALLOW** multiples **IGNORE** state symbols **ALLOW** $CaO + 2H_2O \rightarrow Ca(OH)_2 + H_2O$ **AND** $CaO + H_2O \rightarrow Ca^{2+} + 2OH^-$
		ii	both pH values > 7 **AND** ≤ 14 **AND** pH with SrO > pH with CaO ✓	1 (AO 1.2)	**ALLOW** ranges within these values but ranges must not overlap **Examiner's Comments** These two sub-questions were well answered.
			Total	**2**	
6		i	 Ca shown with either 0 or 8 electrons **AND** N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓ 3 Ca **AND** 2 N **AND** correct charges on ions, i.e. $3Ca^{2+}$ $2N^{3-}$ ✓ Circles **OR** Brackets **NOT** required	2 (AO2.5) (AO1.2)	**CARE**: **ALLOW any** pairing if electrons correct, e.g.  **IF** 8 electrons shown around Ca, 'extra' 3 electrons around N must match symbol for Ca electrons, e.g.  **IGNORE** inner shells **ALLOW** drawing with 3 Ca^{2+} and 2 N^{3-} e.g.  **Examiner's Comments** Most candidates showed a correct, clear 'dot and cross' diagram. Lower attaining candidates sometimes used wrong charges, not enough

					ions or an incorrect number of electrons on N. Covalently-bonded molecules were seen, but rarely.
		ii	$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$ $Ca(OH)_2$ **OR** NH_3 as product ✓ All species correct **AND** correct balancing ✓	2 (AO2.6×2)	**ALLOW** NH_4OH for NH_3 **ALLOW** $Ca_3N_2 + 8H_2O \rightarrow 3Ca(OH)_2 + 2NH_4OH$ **IGNORE** other products **<u>Examiner's Comments</u>** **Exemplar 1**  **Exemplar 2**  Most candidates were given 1 of the 2 available marks for showing the formula of one correct product, $Ca(OH)_2$ or NH_3. The best answers identified both products and were then able to balance the equation. Common errors included 'CaO' as a product and incorrect compounds of nitrogen (see the two responses above). This part discriminated very well.
		iii	 Ca^{2+} shown alternately in **FOUR** circles ✓ O^{2-} shown alternately in **FOUR** circles ✓	2 AO1.1×2	**ALLOW** labels if seen outside circles provided it clear which circle the label applies to **ALLOW** 1 mark for Ca **AND** O shown alternately, each in **FOUR** circles *i.e. with no charges or incorrect charges* **ALLOW** 1 mark for **2+/+2 AND 2−/−2** shown alternately in **FOUR** circles (with no Ca and O) **DO NOT ALLOW** All circles with same ion, *i.e. all* Ca^{2+} ***OR*** *all* O^{2-} **ALLOW** 1 mark for 4 Ca^{2+} **AND** 4O^{2-} but NOT shown alternately e.g. 

					<u>Examiner's Comments</u> Most candidates completed the diagram with correct Ca^{2+} and O^{2-} ions, shown alternately. Many different errors were seen for which 1 of the 2 marks could sometimes be given, e.g. 2+ and 2−, or Ca and O shown alternately. Some candidates used incorrect ions, with N^{3-} the most common as a carry-over from (i) and (ii). Some candidates completed each face of the structure with the same ion, rather than different ions alternately.
		iv	**'Dot and cross' of central N to O OR N** ✓  **Rest of '*dot and cross*' diagram correct** ✓ 	2(AO2.5×2)	**Electrons do NOT need to be shown paired.** **'Dot and cross' of NO_2** **ALLOW** 1st mark for N → O **OR** N=O **DO NOT ALLOW** ions **CARE** For 2nd mark, watch for stray paired **OR** unpaired electrons on central N **ALLOW** 10 electrons around central N atom for 2 marks, i.e.  **<u>Examiner's Comments</u>** N_2O is a very unfamiliar molecule for candidates and they found this 'dot and cross' diagram far more difficult than diagram for Ca_3N_2 in (i). Information in the question clearly stated that a nitrogen atom is in the centre but many diagrams were drawn with the O atom at the centre. It was also fairly common to see NO_2 rather than N_2O. Candidates found the bonding of the O atom to the central N atom easier than the double or dative covalent bond between the two N atoms. Many candidates included lone pairs on the central N atom despite this resulting in a non-linear molecule. (The question states that the molecule is non-linear). It was common to see an expanded octet with 10 electrons

					being involved with the central N atom (a triple and double bond). If correct, this was given, reflecting a candidate's knowledge at this stage of the course. Candidates are advised to take great care in showing clear symbols for electrons (dots and crosses or other symbols). Parts of the diagram where a dot and a cross cannot be distinguished cannot be credited. This part discriminated extremely well.
			Total	**8**	
7	a		$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$ ✓	1	**ALLOW multiples** **IGNORE** state symbols (even if wrong) **Examiner's Comments** Most candidates were able choose hydrochloric acid as the reagent that would form $BaCl_2$ as a product in a neutralisation reaction but a significant number were unable to balance this straightforward equation.
	b		*Increasing size:* Atomic radius increases **OR** more shells **OR** more (electron) shielding ✓ *Attraction* Nuclear **attraction** decreases **OR** (outer) electron(s) experience less **attraction** ✓ *Ionisation energy* Ionisation **energy** decreases **OR** less **energy** needed to remove electron(s) ✓	3	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **IGNORE** more orbitals **OR** more sub-shells *Alternative must refer to shells* **ALLOW** Energy levels for shells **ALLOW more** electron repulsion between shells **IGNORE** just 'shielding' *(more / greater needed)* **IGNORE** 'nuclear shielding' **IGNORE** 'pull' for attraction **IGNORE** 'electrons less tightly held' **IGNORE** 'nuclear charge' for 'nuclear attraction' **IGNORE** 'easier to remove electron' ***Energy is required*** **ALLOW** less energy to oxidise **Examiner's Comments** This question was another one based upon the AS part of the specification, and most candidates secured the first two marking points. The third mark, based upon the idea of less energy needed to remove electron(s) as the group is descended, was not scored by many. Instead, candidates loosely talked about an increasing ease of electron removal.
			Total	**4**	

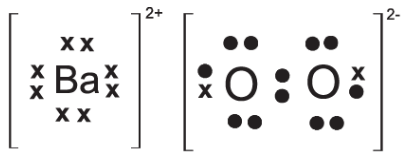
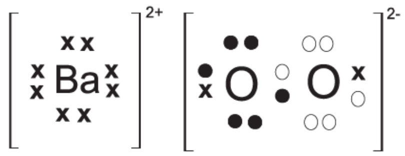
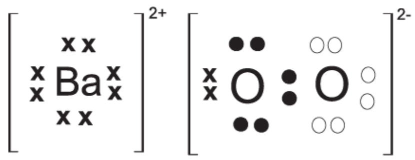
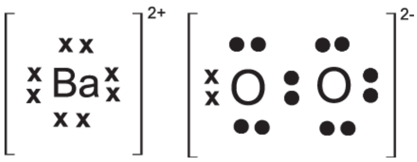
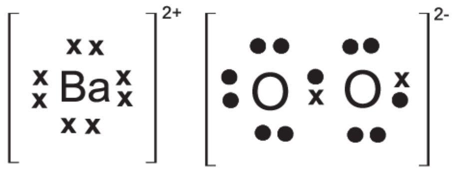
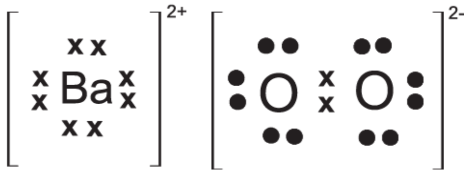
8	a	i	Magnesium (atoms) has been oxidised **AND** Because it has lost **two** electrons ✓ Copper (ions) has been reduced **AND** Because it has gained **two** electrons ✓	2	**IGNORE** use of oxidation numbers if electron gain/loss is mentioned. Electrons gain/loss could be in half equations In the absence of text look for evidence on the equation **ALLOW** 'donated' for 'lost' Assume 'Cu' refers to copper in '$CuSO_4$' **ALLOW** one mark **two** electrons gained and lost for each species but oxidation/reduction is incorrect or is omitted **ALLOW** one mark for correct oxidation and reduction if electron transfer is **omitted** and correct changes of oxidation state are shown (ie Mg 0 --> (+)2 **AND** Cu (+)2 to 0) **ALLOW** '**two** electrons transferred from magnesium to copper **Examiner's Comments** This type of question in the past has proved difficult but the current cohort found little difficulty. By far, the most common error was to use changes in oxidation numbers as the basis of the redox rather than using the number of electrons gained and lost for the explanation of the redox process.
		ii	$Mg(s) + 2H_2O(l)$ ◊$Mg(OH)_2(aq) + H_2(g)$ Correct reactants and products ✓ Balance and state symbols ✓	2	**ALLOW** multiples **ALLOW** $Mg(OH)_2(s)$ **ALLOW** $Mg(s) + H_2O(g)$ **OR** $H_2O(l)$ $MgO(s) + H_2(g)$ including state symbols for **one** mark **Examiner's Comments** The equation for the reaction between magnesium and water was well known – but many erroneously assumed MgO was formed.
	b	i	$Ca(OH)_2$ **OR** Calcium hydroxide **OR** CaO **OR** Calcium oxide ✓ 1	1	**ALLOW** Calcium carbonate **OR** $CaCO_3$ **Examiner's Comments** The unusual equation involving P4 molecules was answered well. Weaker candidates assumed that phosphorus was monatomic and consequentially lost credit.
		ii	$6Ca + P_4$ ◊ $2Ca_3P_2$ ✓	1	**ALLOW** multiples **IGNORE** state symbols **Examiner's Comments**

					This potentially difficult dot-and-cross diagram of the ions present was done well by candidates.
		iii	 Ca with 8 (or no) electrons AND phosphide ion with dot-and-cross outermost octet ✓ Three Ca ions **AND** two phosphide ions with correct charges ✓	2	For first mark: If 8 electrons are shown on the cation then the extra electron in the anion must match the symbol chosen for the electrons in the cation. **IGNORE** inner shells **IGNORE** circles **ALLOW** one mark if both electron arrangements and charges are correct but only one of each ion is drawn. **ALLOW** (brackets not required) $3[Ca^{2+}]$ $3[Ca]^{2+}$ $[Ca^{2+}]_3$ $2[P^{3-}]$ $2[P]^{3-}$ $[P^{3-}]_2$ **DO NOT ALLOW** $[Ca_3]^{2+}$ $[3Ca]^{2+}$ $[Ca]^{32+}$ $[P_2]^{3-}$ $[2P]^{3-}$ $[P]_2$
			Total	**8**	
9		i	$Sr^+(g) \rightarrow Sr^{2+}(g) + e^-$ ✓	1	**ALLOW** $Sr^+(g) - e^- \rightarrow Sr^{2+}(g)$ **ALLOW** e for electron (i.e. charge omitted) **IGNORE** states on the electron **Examiner's Comments** The equation for the second ionisation energy of strontium proved no difficulty for the most able candidates who provided both the correct state symbols and charges. It was surprising however that 40% of candidates failed to score what was meant to be a straightforward mark.
		ii	*Atomic radius* larger atomic radius OR more shells ✓ *Effect of nuclear charge / shielding* Increased nuclear charge outweighed by increased distance / shielding	3	**FULL ANNOTATIONS MUST BE USED** ……………………………………………………. **ALLOW ORA**: comparison needed for each mark. **ALLOW** 'more / higher energy levels' **ALLOW** 'electrons further from nucleus' **ALLOW** 'extra / new shell' **IGNORE** more orbitals OR more sub-shells **OR** different shell

			OR more / increased shielding ✓ *Nuclear attraction* less nuclear attraction **OR** less attraction on electrons ✓		**ALLOW** more electron repulsion from inner shells **IGNORE** responses with no comparison **IGNORE** nuclear charge / effective nuclear charge **ALLOW** 'less nuclear pull' **OR** 'electrons held less tightly' **Examiner's Comments** This descriptive question was well answered with the vast majority of candidates picking up two of the three available marks. Where a candidate scored two marks it was often due to the omission of any comment about the reduction in attraction between the nucleus and the electron as the group was descended. A common error was to discuss the reduction in nuclear charge rather than nuclear attraction.
			Total	**4**	
10	a	i	$2Ca + O_2 \rightarrow 2CaO$ ✓	1	**ALLOW** multiples e.g. $Ca + ½O_2 \rightarrow CaO$ **IGNORE** state symbols **Examiner's Comments** This straightforward equation was well known.
		ii	Thermal decomposition ✓	1	**Examiner's Comments** Some candidates omitted 'thermal' and so did not secure the mark while others wrote out the equation rather than stating the type of reaction.
	b		Effervescence **OR** fizzing **OR** bubbling **OR** gas produced **AND** The solid **OR** calcium **OR** the metal would dissolve **OR** disappear **OR** a (colourless) solution forms ✓ $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ ✓	2	**IGNORE** 'hydrogen produced' but **ALLOW** 'hydrogen gas produced' **DO NOT ALLOW** an incorrectly named gas (eg CO_2) produced **ALLOW** multiples **IGNORE** state symbols **Examiner's Comments** In the observation section most candidates noted effervescence but few then added the necessary observation of the calcium dissolving often despite $Ca(OH)_2(aq)$ appearing in the equation. The equation was well answered generally, although CaOH was not an uncommon species.

3.1.2 Group 2

			Total	**4**	
1 1		i	**Reaction 1:** $Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$ ✓ **Reaction 2:** $Ba_3N_2 + 6H_2O \rightarrow 3Ba(OH)_2 + 2NH_3$ Correct products ✓ Balancing ✓	3	Ignore state symbols **Examiner's Comments** Both equations were relatively challenging. Reaction 1 was a direct question about reactions of Group 2 elements. Reaction 2 demanded a higher level of application based upon information given. Many identified the alkaline gas as NH3, but then incorrectly assumed that the alkaline solution was BaO instead of $Ba(OH)_2$. Weaker candidates suggested equations with hypothetical species that could not have born any relation to formulae that they might have encountered before.
		ii	Giant ionic (lattice) ✓	1	**ALLOW** 'Giant lattice with ionic bonds' **ALLOW** 'Giant ionic bonds' **DO NOT ALLOW** 'atoms or molecules or dipoles' **Examiner's Comments** This question was relatively well answered, although some candidates did negate the mark by referring to molecules of Ba_3N_2 either directly or by indirect reference to intermolecular forces.
		iii		1	Ba must have a 2+ charge Ba can be with or without octet. **IGNORE** lack of charge on O_2^{2-} ion O_2^{2-} ion to have 12 electrons belonging to O atoms + 2 other electrons of another symbol.

			 **OR**  **OR**  **OR** 		The 2 other electrons must match Ba if Ba has an octet. If O electrons are shown as 6 of one symbol and 6 of another, each O must have six electrons of the same symbol **ALLOW**  **OR**  **Examiner's Comments** This question was designed to be difficult, but many candidates rose to the challenge. Weaker candidates simply drew a *'dot-and-cross'* diagram for BaO_2 in which they treated each oxygen species as an oxide ion each having a single negative charge. Many stronger candidates did realise from the structure given in the question that there was only a single bond between the two oxygen atoms, as was clear from their suggested diagram. Only the stronger candidates managed to incorporate correctly the electrons from barium, to arrive at a correct version of the bonding of BaO_2.
			Total	**5**	
1 2		i	$Sr(s) + 2H_2O(l) \rightarrow Sr(OH)_2(aq) + H_2(g)$ **Note: all** state symbols required	1	**allow** multiples
		ii	$n(Sr) = n(Sr^{2+}) = 0.200 / 87.6 = 2.28 \times 10^{-3}$ (1) $[Sr^{2+}] = 2.28 \times 10^{-3} \times 1000 / 250 = 9.13 \times 10^{-3}$ (mol dm^{-3}) (1)	2	**allow ecf**
		iii	Greater volume with Ca **AND** larger amount / more moles of Ca **OR** A_r Ca is smaller (1) $n(Ca) = 0.200/40.1 = 0.005(0)$ (mol) (1)	3	**ora** **allow** values up to calculator values

			volume H_2 with Sr = 55 cm^3 **AND** volume with Ca = 120 cm^3 **OR** 65 cm^3 more H_2 with Ca (1)		**allow** volumes ± 1 cm^3
			Total	**6**	