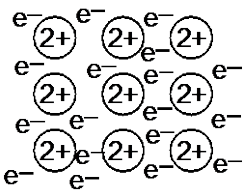
8 Reactivity trends
Answers to practice questions

Question number	Answer	Marks	Guidance
1 (a)	Disproportionation is the simultaneous oxidation and reduction of the same element in the same redox reaction	B1	
1 (b)	Cl has been oxidised from 0 in Cl_2 to +5 in $NaClO_3$ Cl has been reduced from 0 in Cl_2 to –1 in NaCl	B1 B1	
1 (c) (i)	$2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$ 1 mark for equation 1 mark for state symbols	 B1 B1	
1 (c) (ii)	$Cl_2 + 2e^- \rightarrow 2Cl^-$	B1	
1 (c) (iii)	The rate of reaction would be slower because bromine is less reactive that chlorine	B1	
2 (a)	Down a group, electrons are added to a new shell, further from the nucleus There are more inner shells between the outer electrons and the nucleus, increasing the shielding Attraction between nucleus and outer electrons decreases Therefore less energy is required to lose an electron and reactivity of Group 2 increases	B1 B1 B1 B1	
2 (b) (i)	$Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$	B1	
2 (b) (ii)	Group 2 elements react by losing two electrons to form 2+ ions	B1	
3 (a)	 1 mark for showing a regular arrangement of labelled 2+ ions 1 mark for showing delocalised electrons High melting point as the strong attraction between positive ions and delocalised requires a large quantity of energy to be overcome	B1 x 2 B1	Regular arrangement must have at least two rows of correctly charged ions and a minimum of two ions per row **ALLOW** as label: positive ions, cations if correct charge is seen within circle **ALLOW** for labelled Ba^{2+} ions: circles with Ba^{2+} inside **DO NOT ALLOW** incorrect charge for ions eg + , 3+ etc **DO NOT ALLOW** for label of ions: nuclei **OR** positive atom **OR** protons **ALLOW** e– or ‘e’ or – as symbol for electron within the lattice for first marking point if not labelled

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			as 'electrons'. **ALLOW** mobile or 'sea of' for delocalised *Quality of written communication*: 'electron(s)' spelled correctly and used in context for the **third** marking point **ALLOW** a lot of energy is needed to break **OR** overcome the attraction between (positive) ions and (delocalised) electrons **IGNORE** 'heat' but **ALLOW** 'heat energy' **DO NOT ALLOW** references to incorrect particles or incorrect attractions eg 'intermolecular attraction' **OR** 'nuclear attraction' **IGNORE** 'strong metallic bonds' without seeing correct description of metallic bonding
3 (b) (i)	$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$ $Ba(OH)_2$ as product Rest of equation and state symbols	B1 B1	**ALLOW** multiples
3 (b) (ii)	$7 < pH \leq 14$	B1	**DO NOT ALLOW** if pH 7 is in a quoted range
3 (b) (iii)	OH^-	B1	**DO NOT ALLOW** Ba^{2+} **DO NOT ALLOW** any reference to electrons
3 (c)	Magnesium carbonate, hydroxide or oxide	B1	**ALLOW** magnesium carbonate **ALLOW** correct formulae: $Mg(OH)_2$, MgO, $MgCO_3$ **IGNORE** 'milk of magnesia'
3 (d) (i)	Fizzing and solid dissolves $SrCO_3 + 2HCl \rightarrow SrCl_2 + H_2O + CO_2$	B1 B1	**DO NOT ALLOW** 'carbon dioxide produced' without 'gas' **DO NOT ALLOW** 'hydrogen gas produced' **OR** any other named gas **ALLOW** 'it' for strontium carbonate **ALLOW** strontium for strontium carbonate if $SrCO_3$ seen in equation **IGNORE** 'reacts' **IGNORE** references to temperature change **IGNORE** 'steam produced'

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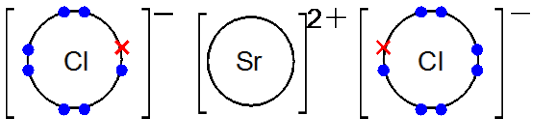
			IGNORE state symbols
3 (d) (ii)	 1 mark for dot and cross being correct 1 mark for ions being correct	B1 x 2	**For first mark**, if eight electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation **IGNORE** inner shell electrons Circles **not** essential **ALLOW** One mark if both electron arrangement and charges are correct but only one Cl is drawn **ALLOW** $2[Cl^{-}]$ $2[Cl]^{-}$ $[Cl^{-}]_2$ (brackets not required) **DO NOT ALLOW** $[Cl_2]^{-}$ $[Cl_2]^{2-}$ $[2Cl]^{2-}$ $[Cl]_2^{-}$
3 (e) (i)	Solution turns orange	B1	**ALLOW** shades and colours containing (eg dark orange, yellow-orange) **ALLOW** the following: yellow, yellow-brown, brown, brown-red BUT **DO NOT ALLOW** red alone **IGNORE** initial colours **DO NOT ALLOW** any response that includes 'precipitate' **OR** solid
3 (e) (ii)	$Cl_2 + 2Br^{-} \rightarrow Br_2 + 2Cl^{-}$	B1	**ALLOW** multiples **IGNORE** state symbols
3 (e) (iii)	Chlorine gains an electron more easily than bromine. An atom of chlorine is smaller than bromine In a chlorine atom, there are fewer shells between the outer electrons and the nucleus than bromine, decreasing shielding In a chlorine atom, the nuclear attraction on an electron to be gained is greater than bromine	B1 B1 B1 B1	Look for ORA from perspective of Br throughout. **ALLOW** all four marks applied to 'as you go up **OR** as you down the group' **ALLOW** Cl for chlorine **AND** Br for bromine **ALLOW** ORA **DO NOT ALLOW** the use of 'ide' BUT **ALLOW** use of 'ide' as an ECF **ALLOW** chlorine is better at electron capture **ALLOW** chlorine has greater electron affinity **IGNORE** chlorine is more electronegative **IGNORE** chlorine has more oxidising power than bromine

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			IGNORE explanations given in terms of displacement **ALLOW** chlorine has fewer shells **ALLOW** the electron is added to the (outer) shell closer to the nucleus **IGNORE** 'easily' for 'greater' or for 'stronger' **ALLOW** 'chlorine has greater nuclear attraction (on its outermost electrons)' **OR** '(the outermost) electrons in chlorine are more attracted (to the nucleus)'
4 (a)	Down a group, reactivity increases Electrons are added to a new shell, further from the nucleus There are more inner shells between the outer electrons and the nucleus, increasing the shielding Attraction between nucleus and outer electrons decreases Therefore less energy is required to lose an electron and reactivity of Group 2 increases	B1 B1 B1 B1 B1	'Down the group' is not required **ORA** throughout **ALLOW** alternative phrases for 'reactivity increases' **ALLOW** 'there are more energy levels' **ALLOW** 'electrons are in higher energy levels' **ALLOW** 'electrons are further from the nucleus' **IGNORE** there are more orbitals **OR** more sub-shells **ALLOW** 'different shell' **OR** 'new shell' There must be clear comparison ie 'more shielding' **OR** 'increased shielding' **ALLOW** there is **more** electron repulsion from inner shells **DO NOT ALLOW** responses which have no comparative eg 'there is shielding' **ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** there is less effective nuclear charge **IGNORE** 'nuclear charge' for 'nuclear attraction' If question is answered in terms of only Group 7, then **ONLY** marks 2, 3 and 4 can be awarded

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			ALLOW easier to oxidise
4 (b) (i)	Aqueous silver nitrate, $AgNO_3(aq)$	B1	**ALLOW** Ag+ (aq)
4 (b) (ii)	A yellow precipitate forms	B1	**ALLOW** shades of yellow but not creamy yellow **ALLOW** ppt or solid for precipitate
4 (b) (iii)	$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$	B1	**ALLOW** correct multiples
4 (b) (iv)	concentrated aqueous ammonia, NH_3	B1	
5 (a) (i)	A white precipitate	B1	**DO NOT ALLOW** goes white / cloudy / milky / off-white **DO NOT ALLOW** creamy white precipitate **ALLOW** milky white precipitate
5 (a) (ii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ 1 mark for species and equation 1 mark for state symbols	 B1 B1	**ALLOW 2 marks** $AgNO_3(aq) + Cl^-(aq) \dashrightarrow AgCl(s) + NO_3^-(aq)$ **(equation mark and state symbol mark)** **ALLOW 1 mark for**: $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ **(state symbol mark)** **ALLOW 1 mark for the state symbols for THESE balanced equation ONLY**: $Ag^{2+}(aq) + 2Cl^-(aq) \dashrightarrow AgCl_2(s)$ $Ag(aq) + Cl(aq) \dashrightarrow AgCl(s)$
5 (a) (iii)	The precipitate dissolved	B1	**ALLOW** forms a solution
5 (b) (i)	Chlorine kills bacteria	B1	**ALLOW** to make water potable **IGNORE** virus **DO NOT ALLOW** 'purifies water' **DO NOT ALLOW** 'antiseptic'
5 (b) (ii)	Chlorine is toxic and can form chlorinated hydrocarbons	B1	**ALLOW** forms carcinogens **OR** forms toxins **DO NOT ALLOW** harmful **DO NOT ALLOW** 'it causes cancer' (chlorine is not a carcinogen) **DO NOT ALLOW** 'irritates lungs'
5 (c) (i)	Cl_2 0; HCl –1; HClO +1 All three correct:	B1	**ALLOW** 1– **ALLOW** 1+
5 (c) (ii)	Chlorine has been both oxidised and reduced	B1	**ALLOW** 'chlorine' **OR** 'it'

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	Cl in Cl_2 has been oxidised from 0 to +1 in HClO AND Cl has been reduced from 0 to –1 in HCl	B1	**DO NOT ALLOW** chlor**IDE** **IF CORRECT OXIDATION STATES IN (i), ALLOW 2 marks for:** it is oxidised to form HClO it is reduced to form HCl
5 (c) (iii)	$Cl_2(g) + 2NaOH(aq) \rightarrow NaCl(aq) + NaClO(aq)$	B1	**IGNORE** state symbols
5 (d) (i)	$2ClO_2 \rightarrow Cl_2 + 2O_2$	B1	**IGNORE** state symbols
5 (d) (ii)	H : Cl : O = 1.20/1.0 : 42.0/35.5 : 56.8/16.0 = 1.20 : 1.18 : 3.55 Formula = $HClO_3$	B1 B1	**ALLOW** 1 mark for empirical formula of HCl_2O_6 (use of atomic numbers) **ALLOW** 1 mark for empirical formula of H_3Cl_3O (upside-down expression) **ALLOW ECF** for use of incorrect A_r values to get empirical formula but only if no over-rounding **ALLOW 2 marks** for correct answer of $HClO_3$
5 (d) (iii)	The oxidation number of Cl is +5	B1	**ALLOW** 'the oxidation state of chlorine **OR** oxidation number of chlorine is 5' **DO NOT ALLOW** 'it' instead of 'chlorine' **DO NOT ALLOW** 'the oxidation state **OR** number of chlor**IDE** is 5'
6 (a)	Boiling point increases down the group from Cl to I, the number of electrons increases, resulting in stronger London forces More energy has to be supplied to break the stronger intermolecular forces	B1 B1 B1 B1	
6 (b) (i)	Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$; Br: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$	B1 B1	
6 (b) (ii)	Ca^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6$; Br^-: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$	B1 B1	
6 (c)	Sr is more reactive than Ca as it is further down Group 2 I is less reactive than Br as it is further down the Halogens	B1 B1	

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	It is difficult predicting which is the more dominant effect	B1	
7 (a) (i)	BaO	B1	Treat any shown charges as working and ignore. Treat B for Ba as a slip.
7 (a) (ii)	Ba_3N_2	B1	Treat any shown charges as working and ignore. Treat B for Ba as a slip.
7 (b) (i)	$n(Ba) = \frac{\text{mass Ba}}{\text{Molar mass Ba}} = \frac{0.11}{137.3}$ [1] = 8.0 × 10^{-4} mol	B1	mark is for the **working out** which **MUST** lead to the correct answer of 8 x 10^{-4} up to calculator value
7 (b) (ii)	$n(H_2) = n(Ba) = 8.0 \times 10^{-4}$ mol Volume = $8.0 \times 10^{-4} \times 24\,000 = 19.2\,cm^3$	B1	**ALLOW** 19 up to calculator value.
7 (b) (iii)	Concentration = $10 \times 8.0 \times 10^{-4} = 8.0 \times 10^{-3}$ mol dm^{-3}	B1	**ALLOW** 8.01 x 10^{-3} up to calculator value.
7 (b) (iv)	pH ~ 14	B1	**ALLOW** a correct range of pH.
7 (c)	There is less barium to react because some has already reacted with air	B1	**ALLOW** less volume because contains some BaO or Ba_3N_2
7 (d)	Down a group, reactivity increases Electrons are added to a new shell, further from the nucleus There are more inner shells between the outer electrons and the nucleus, increasing the shielding Attraction between nucleus and outer electrons decreases Less energy is needed to lose an electron	B1 B1 B1 B1 B1	**DO NOT ALLOW** more orbitals **OR** more sub-shells 'More' *is essential* **ALLOW** 'more electron repulsion from inner shells' **ALLOW** 'nuclear pull' **IGNORE** any reference to 'effective nuclear charge' **ALLOW** easier to form positive ion
8 (a)	The solution contains carbonate ions, CO_3^{2-} from the effervescence with dilute nitric acid. $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$ The solution contains bromide ions, Br^- from the cream precipitate with aqueous silver nitrate that dissolves in concentrated aqueous ammonia. $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$	B1 B1 B1 B1	

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8 (b)	The student would obtain a white precipitate with aqueous barium nitrate Conclusion would be that sulfate ions, SO_4^{2-} are present introduced with the sulfuric acid $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$	B1 B1 B1	
9	Add aqueous silver nitrate to each solution, followed by concentrated ammonia The bromide solutions produce a cream precipitate which dissolved in concentrated ammonia The iodide solutions produce a yellow precipitate which does not dissolved concentrated ammonia $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ (or equation with I^-) Heat solutions with aqueous sodium hydroxide The ammonium solutions produce an alkaline gas/ammonia which turns indicator paper blue $NH_4(aq) + OH^-(aq) \rightarrow NH_3 + H_2O$ OR $NH_4Br(aq) + NaOH(aq) \rightarrow NaBr(aq) + NH_3 + H_2O$	B1 B1 B1 B1 B1 B1 B1	