

Question			Answer	Marks	Guidance
1	(a)		$\text{Ba}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$ ✓	1	ALLOW multiples IGNORE state symbols (even if wrong)
	(b)		<i>Increasing size:</i> Atomic radius increases OR more shells OR more (electron) shielding ✓ <i>Attraction</i> Nuclear attraction decreases OR (outer) electron(s) experience less attraction ✓ <i>Ionisation energy</i> 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 <i>Alternative must refer to shells</i> ALLOW Energy levels for shells ALLOW more electron repulsion between shells IGNORE just 'shielding' (<i>more/greater needed</i>) IGNORE 'nuclear shielding' IGNORE 'pull' for attraction IGNORE 'electrons less tightly held' IGNORE 'nuclear charge' for 'nuclear attraction' IGNORE 'easier to remove electron' <i>Energy is required</i> ALLOW less energy to oxidise

Question			Answer	Marks	Guidance
1	(c)	(i)	<i>Disproportionation:</i> oxidation and reduction of the same element ✓ <i>Redox:</i> Cl is oxidised from +5 (in KClO_3) to +7 (in KClO_4) ✓ Cl is reduced from +5 (in KClO_3) to -1 (in KCl) ✓	3	ALLOW 'chlorine' OR 'Cl' for same element IGNORE 'species' for 'element' ALLOW after number, e.g. 5+ IGNORE ionic charges, e.g. Cl^{5+} IGNORE '5' (signs required) IGNORE any reference to electron loss/gain (even if wrong) ALLOW one redox mark if oxidation numbers are correct but reduction/oxidation is incorrectly assigned
		(ii)	potassium chlorate(VII) ✓	1	Brackets required

Question	Answer	Marks	AO element	Guidance
2	C	1	AO1.2	

Question	Answer	Marks	AO element	Guidance
3	D	1	AO2.3	

Question			Answer	Marks	Guidance
4	(a)		ASSUME trend is down the group (unless stated otherwise) Forces London forces increase OR induced dipole(–dipole) interactions increase ✓ Reason (Number of) electrons increases ✓ Link to energy and particles More energy to break intermolecular forces OR to break London forces OR to break induced dipole(–dipole) interactions ✓	3	FULL ANNOTATIONS MUST BE USED ----- ALLOW reverse argument throughout IGNORE van der Waals'/vdW forces DO NOT ALLOW hydrogen bonds OR permanent dipole(-dipole) interactions for first and third marking points ALLOW more (electron) shells DO NOT ALLOW covalent bonds break

Question	Answer	Marks	AO	Guidance
5	C	1	AO1.2	

Question	Answer	Marks	AO	Guidance
6	B	1	AO1.1	

Question			Answer	Marks	AO	Guidance
	7(a)	(i)	$\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$ ✓	1	2.8	ALLOW multiples IGNORE state symbols ALLOW $\text{CaO} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2\text{O}$ AND $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}^{2+} + 2\text{OH}^-$
		(ii)	both pH values > 7 AND ≤ 14 AND pH with SrO $>$ pH with CaO ✓	1	1.2	ALLOW ranges within these values but ranges must not overlap

Question	Answer	Marks	AO	Guidance
8	D	1	1.2	ALLOW 1 in the answer box

Question		Answer	Marks	AO element	Guidance
9	(a)	Interpretation of Results Orange contains bromine AND no reaction AND violet contains iodine ✓ Ionic equation $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$ ✓ Reactivity (down the group) Reactivity decreases AND oxidising power decreases OR gains electrons less easily OR forms negative ion/$1-$ ion less easily OR less energy released when electron gained ✓ OR more negative electron affinity Size/shells/shielding (down the group) Greater atomic radius OR more shells OR more shielding ✓ Attraction (down the group) Less nuclear attraction down the group ✓	5	2.3× 1 2.6×1 1.1×3	Results can be interpreted anywhere in answer. ALLOW multiples, e.g. $\frac{1}{2}\text{Br}_2 + \text{I}^- \rightarrow \text{Br}^- + \frac{1}{2}\text{I}_2$ IGNORE other halogen/halide equations IGNORE state symbols ALLOW ORA DO NOT ALLOW idea of losing electrons/ionisation energy IGNORE chlorine is the most electronegative IGNORE explanations in terms of displacement

Question			Answer	Marks	AO element	Guidance
	(b)		<i>Benefit AND risk required for ONE mark</i> Benefit: kills bacteria ✓ AND Risk: toxic/poisonous OR forms chlorinated hydrocarbons OR forms carcinogens/toxic compounds ✓	1	1.1	ALLOW kills micro-organisms OR kills pathogens OR kills viruses OR sterilises/disinfects water IGNORE antiseptic, reduces risk of disease, cleans water IGNORE 'harmful'/'dangerous' IGNORE chlorine is carcinogenic/ dangerous for health/causes breathing problems

Question	Answer	Marks	AO element	Guidance
10	D	1	AO1.1	Accept 1

Question	Answer	Marks	AO	Guidance
11	D	1	2.7	

Question			Answer	Marks	AO element	Guidance
12	(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
12		(ii)	Oxidation $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ ✓ Reduction $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ OR $\text{H}^+ + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2$ ✓	2	AO2.6 ×2	In half equations, ALLOW the use of e ⁻ ALLOW $\text{Mg} - 2\text{e}^- \rightarrow \text{Mg}^{2+}$ 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

Question	Answer	Marks	AO element	Guidance
13	D	1	AO2.3	

Question	Answer	Marks	Guidance
14	B	1	

Question	Answer	Marks	Guidance
15	C	1	

Question	Answer	Marks	Guidance
16	D	1	

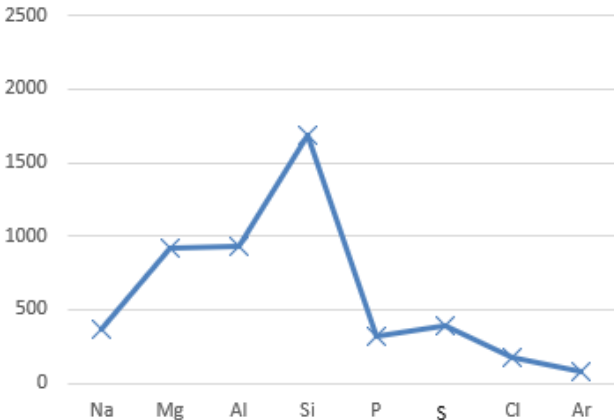
Question	Answer	Marks	Guidance
17	D	1	

Question			Answer	Marks	Guidance
18	(a)	(i)	killing bacteria ✓	1	ALLOW killing microorganisms / microbes / sterilises water IGNORE 'removing' bacteria
		(ii)	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓ Chlor <u>ine</u> is more reactive than brom <u>ine</u> AND iod <u>ine</u> is less reactive than brom <u>ine</u> OR chlor <u>ine</u> is a stronger oxidising agent than brom <u>ine</u> AND iod <u>ine</u> is a weaker oxidising agent than brom <u>ine</u> . ✓	2	DO NOT ALLOW full equation IGNORE state symbols CARE with endings (e.g. ide and ine) ALLOW ORA ALLOW reactivity $Cl > Br > I$ ALLOW brom <u>ide</u> is a stronger reducing agent than chlor <u>ide</u> AND brom <u>ide</u> is a weaker reducing agent than iod <u>ide</u> IGNORE displacement IGNORE references to down the group. IGNORE all comparisons of electron structure/electron affinity

18	(b)*	Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Describe the types of structure and bonding of all four elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Attempt to describe the types of bonding of three elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles. OR Describe in detail and bonding of two of the three types of structure AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Attempt to describe the bonding of two elements AND explains most of the differences in melting points in terms of the relative strengths of the forces between the particles. OR Describes in detail the bonding of one of the three types of structure AND explains the melting point in terms of the strength of the forces between the particles.	6	Indicative scientific points may include: ALLOW minor omissions as we are looking for a holistic approach to LoR marking. Al (Giant metallic) • Giant metallic structure/lattice • Strong metallic bonding • Electrostatic attraction between (positive) metal ions/cations and delocalised electrons • A lot of energy needed to break bonds Si (Giant covalent) • Each Si atom forms 4 bonds / bonds with 4 other Si atoms • Giant covalent structure/lattice • Strong covalent bonds between atoms • Between shared pair of electrons and adjacent nuclei. • Most energy needed to break bonds P, S (Simple covalent) • <u>Simple</u> covalent / molecular structure/lattice • Strong covalent bonds between atoms • Weak induced dipole–dipole interactions between molecules* • Least energy to overcome the forces • Melting point of $S_8 > P_4$ • More electrons • Stronger induced dipole–dipole interactions • DO NOT ALLOW breaks BONDS • IGNORE van der Waals' (VDW)
----	------	---	---	---

Question			Answer	Marks	Guidance
19	(a)		$2 \text{ Ba} + \text{O}_2 \rightarrow 2 \text{ BaO}$ ✓ $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba(OH)}_2$ ✓ Neutralisation OR acid-base ✓	3	ALLOW multiples IGNORE state symbols, even if incorrect ALLOW $\text{Ba} + \text{H}_2\text{O} \rightarrow \text{BaO} + \text{H}_2$ (reaction with steam) ALLOW other correct equations e.g. with less reactive metal oxide

Question	Answer	Marks	Guidance
20	B	1	

Question			Answer	Mark	Guidance																		
21	(a)	(i)	S higher than P AND P higher than C/ AND Cl higher than Ar ✓ All points / line below the height of Mg ✓	2	 <table border="1"><thead><tr><th>Element</th><th>Bond Energy (kJ/mol)</th></tr></thead><tbody><tr><td>Na</td><td>350</td></tr><tr><td>Mg</td><td>900</td></tr><tr><td>Al</td><td>900</td></tr><tr><td>Si</td><td>1700</td></tr><tr><td>P</td><td>300</td></tr><tr><td>S</td><td>400</td></tr><tr><td>Cl</td><td>200</td></tr><tr><td>Ar</td><td>100</td></tr></tbody></table>	Element	Bond Energy (kJ/mol)	Na	350	Mg	900	Al	900	Si	1700	P	300	S	400	Cl	200	Ar	100
Element	Bond Energy (kJ/mol)																						
Na	350																						
Mg	900																						
Al	900																						
Si	1700																						
P	300																						
S	400																						
Cl	200																						
Ar	100																						
		(ii)	Al giant (metallic) AND Si giant (covalent) ✓ Al metallic AND Si covalent ✓ Covalent bonds (in Si) stronger / more energy needed to break covalent bonds (than metallic in Al) ✓	3	ALLOW macromolecular for Si ALLOW correct description of each bonding type CON if intermolecular forces are compared in Al																		

Question			Answer	Mark	Guidance
21	(b)		(aqueous bromine + sodium iodide) (Orange solution) turns brown ✓ (aqueous bromine + sodium chloride) Stays orange ✓ $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$ ✓	3	ALLOW one mark for only final colours ALLOW shade of brown for dilute I_2 DO NOT ALLOW purple DO NOT ALLOW incorrect colour for aqueous bromine ALLOW shade of orange for dilute Br_2 ALLOW No colour change IGNORE No reaction / No change DO NOT ALLOW <u>turns</u> orange ALLOW multiples, e.g. $\frac{1}{2}\text{Br}_2 + \text{I}^- \rightarrow \text{Br}^- + \frac{1}{2}\text{I}_2$ IGNORE state symbols IGNORE half-equations, even if wrong