

2(a)(i)	halogen	colour	state	2
	chlorine	yellow / green	gas	
	bromine	red / brown / orange	liquid	
	iodine	grey / black	solid	
2(a)(ii)	increasing number of electrons			1
	(gives) increasing strength of van der Waals' / id-id forces / London / dispersion forces			1
2(c)(i)	solid sodium chloride: steamy / misty / white fumes			1
	solid sodium iodide: purple fumes			1
2(c)(ii)	(conc sulfuric) not powerful enough oxidising agent (to oxidise chloride) OR chloride not powerful enough reducing agent (to reduce sulfuric acid)			1
	iodide reduces sulfuric acid OR iodide / I ⁻ is oxidised OR sulfuric acid oxidises iodide			1

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Question	Answer	Marks
2(d)(ii)	AgCl (precipitate) dissolves (in ammonia) owtte	1
	Total:	15

Question	Answer	Marks
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May/June 2017 9701/23 · Q2 (a)(i), (a)(ii), (c)(i), (c)(ii), (d)(ii)

3(a)(i)	(volatility) decreases			1
3(a)(ii)	increasing numbers / more of electrons (in molecules)			1
	increased strength of id-id / VdW / IMFs			1
3(b)	$\text{Cl}_2 + 2\text{NaI} \rightarrow 2\text{NaCl} + \text{I}_2$			1
3(c)(i)				3
		$\text{NaI(aq)} + \text{AgNO}_3\text{(aq)}$	$\text{NaCl(aq)} + \text{AgNO}_3\text{(aq)}$	
	colour of ppt	yellow	white	
	name of ppt	silver iodide	silver chloride	
	effect of addition of aqueous ammonia to the precipitate	No (visible) change	dissolves / soluble	
3(c)(ii)	$\text{Ag}^+\text{(aq)} + \text{I}^-\text{(aq)} \rightarrow \text{AgI(s)}$			1

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Question	Answer	Marks
3(d)	M1 sulfuric acid acts as an acid with NaCl (and NaBr) OR $\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$ OR $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}$	1
	sulfuric acid acts as an oxidising agent with NaI / I^- OR NaI is a reducing agent	1
	I^- more powerful reducing agent than Cl^- OR sulfuric acid can oxidise I^- but not Cl^- OR sulfuric acid is a stronger oxidising agent than iodide ions OR sulfuric acid is not as strong an oxidising agent than chloride ions	1
3(e)(i)	(Species that) gains <u>electrons</u> / <u>electron</u> acceptor	1
3(e)(ii)	$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + \text{HClO}$	1

May/June 2018 9701/23 · Q3 (a)(i), (a)(ii), (b), (c)(i), (c)(ii), (d), (e)(i), (e)(ii)

2(a)	<i>trend in volatility down the group</i>	1
	decrease (in volatility)	
	<i>identification of specific IMF increasing</i>	
	increasing (strength of) induced dipole (id) (interactions between molecules)	1
	<i>explanation in terms of electrons</i>	
	increasing number of electrons	
2(b)(i)	Conditions for reaction with Cl ₂ at room temperature ultra-violet / uv	1

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Question	Answer	Marks
2(b)(ii)	I ₂ (g / s) + H ₂ (g) ⇌ 2HI(g)	1
	M1 correctly balanced equation	
	M2 correct state symbols AND use of <u>equilibrium</u> sign	
2(c)(iii)	co-ordinate / dative (covalent)	1

May/June 2019 9701/22 · Q2 (a), (b)(i), (b)(ii), (c)(iii)

3(c)	2NaOH + HCl + HClO → NaCl + NaClO + 2H ₂ O	2
	M1 Identifies the product NaClO	
	M2 Correctly balances the equation	
	OR	
	The overall equation may be seen as: NaOH + HCl → NaCl + H ₂ O AND NaOH + HClO → NaClO + H ₂ O	

Question	Answer	Marks
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May/June 2019 9701/22 · Q3 (c)

1(b)	M1: decreases (down the group)	3
	M2: increasing induced dipoles	
	M3: greater number of electrons	

Oct/Nov 2019 9701/21 · Q1 (b)

2(a)	darker / stronger / deeper down the group	1
2(b)(i)	weaker oxidising agents / (relative reactivity as oxidising agents) decreases down the group	1
2(b)(ii)	M1 (structure =) simple / molecular, because it has a low melting / boiling point M2 (bonding =) covalent, because it is hydrolysed	2
2(c)(i)	M1 cream ppt / solid M2 (ppt / solid) partially dissolves in (aqueous) ammonia	2

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Question	Answer	Marks
2(c)(ii)	M1 <i>Acid behaviour of H₂SO₄</i> H ₂ SO ₄ acts as an acid with Cl ⁻ OR acid / base reaction with Cl ⁻ M2 <i>Oxidising behaviour of H₂SO₄</i> H ₂ SO ₄ acts as an oxidising agent with I ⁻ OR H ₂ SO ₄ does not oxidise Cl ⁻ M3 <i>Products formed</i> (for iodide reaction) I ₂ / S / SO ₂ / H ₂ S is formed OR (for chloride reaction) (only) HCl is formed OR <i>Comparison of oxidising strength</i> H ₂ SO ₄ not strong enough to / cannot oxidise Cl ⁻ (to Cl ₂) OR I ⁻ more powerful reducing agent than Cl ⁻	3
2(d)(i)	M1 increases (down the group) because of increasing VdW M2 because of increasing number of electrons	2
2(d)(ii)	M1 less stable (down the group) / decreases M2 lower H–Hal bond enthalpy / energy	2

March 2020 9701/22 · Q2 (a), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(i), (d)(ii)

4(a)(i)	M1: (Volatility) decreases (down the group) M2: more electrons so greater intermolecular forces / intermolecular attractions OR more electrons so greater VdW between molecules	2
4(a)(ii)	(HI has the) lowest bond enthalpy	1
4(c)(i)	2-iodo(-)2(-)methylbutane	1

Oct/Nov 2020 9701/21 · Q4 (a)(i), (a)(ii), (c)(i)

1(a)(i)	increases	1
1(a)(ii)	chlorine gas bromine liquid iodine solid	1
1(b)	M1 observation with $\text{Cl}_2(\text{aq})$ (colourless / pale green to) orange / brown	1
	M2 observation with $\text{I}_2(\text{aq})$ no visible change	1
	M3 explanation chlorine is a stronger oxidising agent (than bromine) AND iodine is a weaker oxidising agent	1
1(c)	$\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$	1
1(d)(i)	proton / H^+ acceptor	1
1(d)(ii)	$\text{ClO}^- + \text{H}_2\text{O} \rightarrow \text{HClO} + \text{OH}^-$	1
1(e)	M1 Use volume O_2 to express / find no mol O_2 produced $24 / 24\,000$ mol O_2 produced = 1×10^{-3} (mol)	1
	M2 Use 1:1 ratio to deduce no mol NaClO in 1000 cm^3 sample $\text{M1} \times 1000 / 5 = 0.2$ (mol dm^{-3})	1
	M3 Use amount of NaClO and its molecular mass (74.5) to find the mass of NaClO added $24 / 24\,000 \times 1000 / 5 \times 74.5 = 14.9$ (g dm^{-3})	1

May/June 2021 9701/23 · Q1 (a)(i), (a)(ii), (b), (c), (d)(i), (d)(ii), (e)

3(a)	M1: reaction less vigorous (down the group) M2: Any two of the following for one mark: • electronegativity decreases • less attractive to e^- addition • weaker oxidising agent • greater nuclear charge outweighing increased shielding (ENC argument)	2
3(b)(i)	$\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{HCl}$	1
3(c)	$\text{H}-\text{Cl}$ bond is stronger than $\text{H}-\text{I}$ / BDE decreases down the group	1
3(e)(ii)	2° carbocation more stable (than 1°) (or reverse argument) [1] greater positive inductive effect of two methyl groups (cf. one ethyl) (or reverse argument) [1]	2

March 2022 9701/22 · Q3 (a), (b)(i), (c), (e)(ii)

2(b)(i)	M1 $2\text{NaTs} + \text{Br}_2 \rightarrow 2\text{NaBr} + \text{Ts}_2$ OR $2\text{Ts}^- + \text{Br}_2 \rightarrow 2\text{Br}^- + \text{Ts}_2$ M2 Ts^- reduces Br / Br_2 OR reducing strength of halide (ion) increases down the group	2
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May/June 2022 9701/23 · Q2 (b)(i)

5(b)(ii)	chlorine / Cl AND peak at $\text{M}+2$ represents the molecular ion with $37-\text{Cl}$ (rather than $35-\text{Cl}$ as relative abundance of (peaks) M : $\text{M}+2$ is 100:33 / 3:1) OR relative abundance of (peaks) M : $\text{M}+2$ is 100:33.3 / 3:1 (so peak at $\text{M}+2$ contains $37-\text{Cl}$)	1
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May/June 2022 9701/23 · Q5 (b)(ii)

1(a)	halogen	colour at 293 K	All three correct for one mark	1
	chlorine	green		
	bromine	brown		
	iodine	(dark) grey		
1(b)	M1 (it / volatility) decreases M2 more electrons in molecules M3 (so) increased strength of instantaneous dipole – induced dipole forces (of attraction)			3
1(c)(i)	$\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$			1
1(c)(ii)	(Br ₂ / bromine is an) oxidising agent AND removes electron(s) from iodide (ions) I ⁻ OR increases the oxidation number of I ⁻ / iodide (ion)			1
1(d)(i)	NaBr + H ₂ SO ₄ → HBr + NaHSO ₄ OR 2NaBr + H ₂ SO ₄ → 2HBr + Na ₂ SO ₄			1

May/June 2024 9701/21 · Q1 (a), (b), (c)(i), (c)(ii), (d)(i)

2(a)(ii)	oxidising strength decreases from chlorine to iodine	1
2(a)(iii)	green colour disappears	1
2(a)(iv)	H—Hal covalent bond strength decreases down the group	1
2(b)(ii)	ultraviolet	1
2(b)(iii)	$\text{C}_2\text{H}_6 + \text{Cl}^\bullet \rightarrow \text{C}_2\text{H}_5^\bullet + \text{HCl}$	1
	$\text{C}_2\text{H}_5^\bullet + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}^\bullet$	1
2(c)(iv)	M1 white precipitate/white ppt forms	1
	M2 CHCl_3 is hydrolysed / chloride ions are released OR Cl^- / chloride ions which are released react with Ag^+ OR silver chloride / AgCl is formed	1

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Question	Answer	Marks
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Oct/Nov 2024 9701/21 · Q2 (a)(ii), (a)(iii), (a)(iv), (b)(ii), (b)(iii), (c)(iv)

2(c)(iv)	M1 white precipitate/white ppt forms	1
	M2 CHCl_3 is hydrolysed / chloride ions are released OR Cl^- / chloride ions which are released react with Ag^+ OR silver chloride / AgCl is formed	1

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Question	Answer	Marks
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Oct/Nov 2024 9701/23 · Q2 (c)(iv)

1(a)(ii)	$2Al + 3Cl_2 \rightarrow 2AlCl_3$			1																
1(a)(iii)	purple (gas) disappears			1																
1(b)(i)	M1 Br—Br is weaker (than Cl—Cl) AND Br atoms are larger M2 less (significant) overlap of orbitals (in Br-Br)			2																
1(b)(ii)	HCl is more thermally stable			1																
1(c)(i)	<table><tr><td></td><td>NaCl</td><td>NaBr</td><td>NaI</td></tr><tr><td>with Ag⁺(aq)</td><td>white precipitate</td><td>M1 cream / off-white ppt</td><td>M2 yellow ppt</td></tr><tr><td>with conc. H₂SO₄</td><td>acid – base</td><td>acid – base, then redox</td><td>acid – base, then redox</td></tr><tr><td>observations with conc. H₂SO₄</td><td>M3 steamy fumes OR fizzing</td><td>M4 brown liquid OR fizzing</td><td> • black solid • yellow solid • effervescence </td></tr></table>				NaCl	NaBr	NaI	with Ag ⁺ (aq)	white precipitate	M1 cream / off-white ppt	M2 yellow ppt	with conc. H ₂ SO ₄	acid – base	acid – base, then redox	acid – base, then redox	observations with conc. H ₂ SO ₄	M3 steamy fumes OR fizzing	M4 brown liquid OR fizzing	• black solid • yellow solid • effervescence	4
	NaCl	NaBr	NaI																	
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Question	Answer	Marks
1(c)(ii)	M1 black solid = iodine / I ₂ AND yellow solid = sulfur / S ₈ M2 effervescence = hydrogen sulfide / H ₂ S(g)	2
1(d)(i)	M1 MgCl ₂ (is ionic and) has mobile ions M2 SiCl ₄ is covalent AND no charge carriers OR (no ions and) no delocalised electrons OR no mobile / moving ions	2
1(d)(ii)	M1 MgCl ₂ pH = 7 M2 SiCl ₄ pH 0 – 4	2

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Question	Answer	Marks
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Oct/Nov 2025 9701/24 · Q1 (a)(ii), (a)(iii), (b)(i), (b)(ii), (c)(i), (c)(ii), (d)(i), (d)(ii)