

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 $\text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2$. I^- loses electrons and is the reducing agent.

2.2 Chlorine: pale-green gas; bromine: red-brown liquid; iodine: grey-black solid. Iodine vapour is purple, not its ordinary solid appearance.

2.3 Iodine has more electrons/more polarisable cloud, stronger London forces. Its larger radius/more shielding weakens attraction for an incoming electron.

3.1 $3\text{Cl}_2 + 6\text{OH}^- \rightarrow 5\text{Cl}^- + \text{ClO}_3^- + 3\text{H}_2\text{O}$. Chlorine changes $0 \rightarrow -1$ and $0 \rightarrow +5$, so five atoms gain one electron each for every atom losing five.

3.2 NaCl releases HCl by acid–base reaction, with no reduction of sulfuric acid. Bromide/HBr can reduce the acid: $2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O}$. SO_2 contains sulfur reduced from +6 to +4. This is a hazardous controlled demonstration.

3.3 $\text{F}_2 > \text{Cl}_2 > \text{At}_2$ from increasing radius/shielding and weaker attraction for an incoming electron down the group. $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HClO}$. $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}$. Disinfection reduces microbial disease; toxicity/harmful by-products require controlled dosing and monitoring.