

Group 17

A-Level Chemistry

Physical properties of the halogens



Bromine is a Group 17 halogen — a dark liquid that gives off an orange vapour.

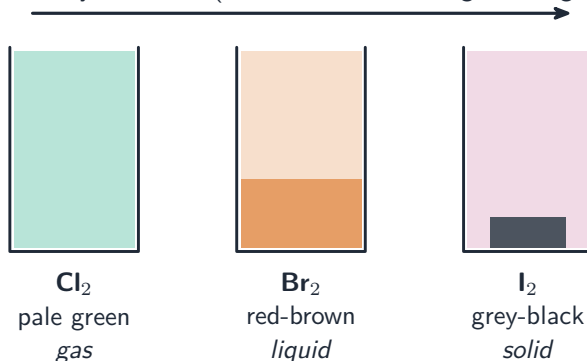
Image: W. Oelen, CC BY-SA 3.0 (commons.wikimedia.org)

The **halogens** 卤素 are the **Group** 族 17 elements. They exist as diatomic molecules (Cl_2 , Br_2 , I_2). Going down the group:

Element	Colour and state at room temperature
chlorine	pale green gas
bromine	red-brown liquid
iodine	grey-black solid (purple vapour)

The **volatility** 挥发性 (how easily a substance turns to vapour) **decreases** down the group: chlorine is a gas, but iodine is a solid. This is because the molecules get larger and have more electrons, so the **instantaneous dipole** 瞬时偶极 and **induced dipole** 诱导偶极 forces between them get stronger. Stronger forces are harder to break, so the boiling point rises and volatility falls.

volatility decreases (intermolecular forces get stronger)



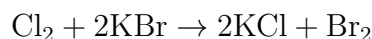
Down Group 17 the halogens change from a pale green gas to a red-brown liquid to a grey-black solid as volatility falls

The **bond energy** 键能 (bond strength) of the X–X molecules generally falls from Cl₂ to I₂, because the shared electrons are further from the nuclei in the larger atoms.

Chemical properties of the halogens and hydrogen halides

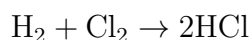
Halogens as oxidising agents

Each halogen reacts by gaining one electron to form a 1– ion, so it acts as an **oxidising agent** 氧化剂. This power **decreases** down the group, because the larger atoms attract an extra electron less strongly. A more reactive halogen can push out a less reactive one from its salt:



Reactions with hydrogen

Each halogen reacts with hydrogen to form a **hydrogen halide** 卤化氢:



The reaction gets less vigorous down the group: chlorine reacts explosively in light, bromine needs heat, and iodine reacts slowly and only partly.

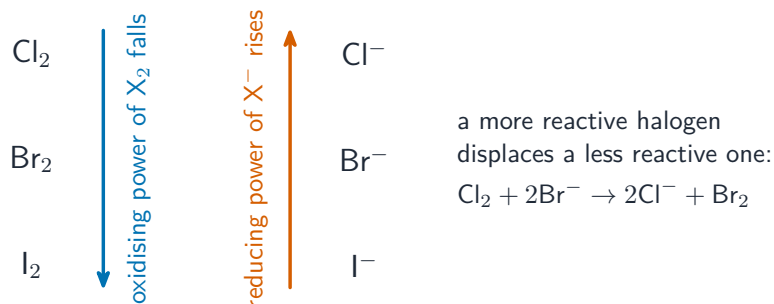
Thermal stability of the hydrogen halides

The **thermal stability** 热稳定性 of the hydrogen halides **decreases** down the group. The H–X bond gets weaker as the halogen atom gets larger, so HI breaks apart on gentle heating while HCl is very stable.

Reactions of the halide ions

Halide ions as reducing agents

A **halide ion** 卤离子 (such as Cl^-) can give away an electron, acting as a **reducing agent** 还原剂. This power **increases** down the group, because a larger ion holds its outer electron less tightly.

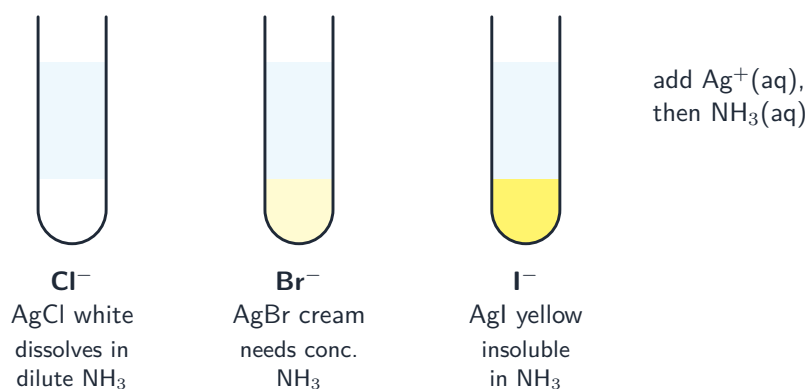


Two opposite trends: the oxidising power of the halogens falls down the group, while the reducing power of the halide ions rises

Reaction with aqueous silver ions

Add aqueous silver nitrate, then aqueous **ammonia** 氨, to identify the halide from the colour of the silver halide **precipitate** 沉淀:

Halide	Precipitate with Ag ⁺	Solubility in ammonia
Cl ⁻	white	dissolves in dilute ammonia
Br ⁻	cream	dissolves only in concentrated ammonia
I ⁻	yellow	insoluble in ammonia



Silver halide precipitates: AgCl is white, AgBr cream and AgI yellow —and their solubility in ammonia confirms which halide is present

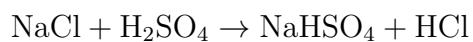


The silver halide test: AgCl is white, AgBr cream and AgI yellow

Image: Rrausch1974, CC BY-SA 3.0 (commons.wikimedia.org)

Reaction with concentrated sulfuric acid

All the halides first give the hydrogen halide. The lower halides are then oxidised by the acid, because they are stronger reducing agents:



- chloride gives only HCl (no redox).
- bromide also gives some brown Br₂ and SO₂.
- iodide gives I₂ and the smelly gases H₂S and SO₂, because I⁻ is the strongest reducing agent.

Reactions of chlorine



Chlorine is added to pool water to kill microbes.

Image: Kritzolina, CC BY-SA 4.0 (commons.wikimedia.org)

With sodium hydroxide

With **cold, dilute** sodium hydroxide, chlorine reacts to form chloride and chlorate(I):



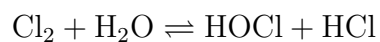
With **hot, concentrated** sodium hydroxide, it forms chloride and chlorate(V):



In both, the **oxidation number** 氧化数 of chlorine goes both up and down (from 0), so both are **disproportionation** 歧化 reactions.

Chlorine in water purification

A little chlorine is added to water for **water purification** 水净化. It reacts with water:



The active species HOCl and ClO^- kill **bacteria** 细菌, making the water safe to drink.