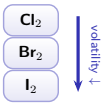
Group 17

A-Level Chemistry ▪ Topic 11

A-Level Chemistry



What we will cover

1. States & volatility
2. Oxidising power & displacement
3. The silver halide test
4. Halides & sulfuric acid
5. Reactions of chlorine

chlorine kills microbes

1 The halogens

States and volatility

Down Group 17 the molecules get larger, so instantaneous dipole–induced dipole forces get stronger. Melting and boiling points rise.

F_2	Cl_2	Br_2	I_2
pale yellow gas	green gas	red-brown liquid	grey-black solid

Colour, state, and bond strength down the group

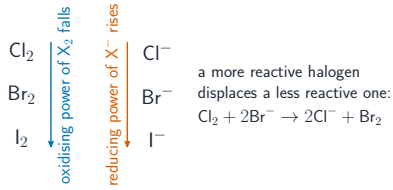
Element	Colour and state at room temperature
chlorine	pale green gas
bromine	red-brown liquid
iodine	grey-black solid, sublimes to a purple vapour

The **bond energy** 键能 of X–X generally falls from Cl_2 to I_2: the shared pair sits further from both nuclei. That is why the reaction with hydrogen gets less vigorous down the group – chlorine explodes in light, bromine needs heat, iodine reacts slowly and only partly.

Oxidising power and displacement

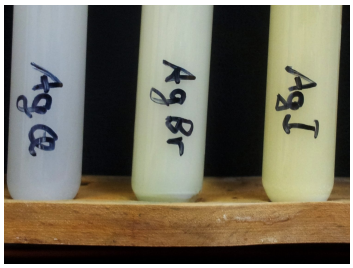
- halogens gain an electron – **oxidising power** 氧化能力 falls down
- **halide ions** 卤离子 lose an electron – **reducing power** 还原能力 rises down

A more reactive halogen displaces a less reactive one: $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$.



a more reactive halogen displaces a less reactive one: $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$

The silver halide test



Add Ag^+, then **ammonia** 氨, to identify the halide:

- Cl^- – white, dissolves in dilute NH_3
- Br^- – cream, only in conc. NH_3
- I^- – yellow, insoluble

Silver halide precipitates

add $Ag^+(aq)$, then $NH_3(aq)$

Cl^-	Br^-	I^-
AgCl white	AgBr cream	AgI yellow
dissolves in dilute NH_3	needs conc. NH_3	insoluble in NH_3

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

Halides with concentrated sulfuric acid

reducing power increases ↓

$Cl^- \rightarrow$ HCl only (no redox)

$Br^- \rightarrow$ HBr, then $Br_2 + SO_2$

$I^- \rightarrow$ HI, then $I_2 + H_2S + SO_2$

The stronger reducing agents are oxidised by the acid:

- Cl^- – only HCl (no redox)
- Br^- – also Br_2 & SO_2
- I^- – I_2, H_2S & SO_2 (strongest reducer)

2 Chlorine

Reactions of chlorine

cold dilute NaOH: $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$

hot conc. NaOH: $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

Both are **disproportionation** 歧化 (Cl goes up *and* down from 0). In water, $Cl_2 + H_2O \rightleftharpoons HOCl + HCl$ – HOCl kills **bacteria** 细菌.

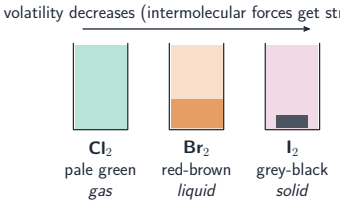
With sodium hydroxide

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

Physical properties of the halogens

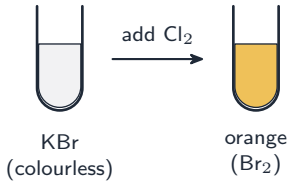
Bromine is a Group 17 halogen – a dark liquid that gives off an orange vapour.

Down Group 17 the halogens change from



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

Halogens as oxidising agents



Chlorine displaces bromine: the solution turns orange

Thermal stability, and chlorine in water

a hydrogen halide 卤化氢	HF, HCl, HBr, HI
thermal stability 热稳定性	decreases down the group – HI decomposes most easily
why	the H–X bond gets longer and weaker as the halogen atom grows
chlorine in water	disproportionates: $Cl_2 + H_2O \rightleftharpoons HCl + HOCl$
water purification 水处理	the active species HOCl and ClO^- kill **bacteria** 细菌, making the water safe to drink
the oxidation number 氧化数 point	chlorine goes from 0 to both −1 and +1 in one reaction – that is what disproportionation means

With concentrated H_2SO_4: NaCl gives HCl only, NaBr also gives brown Br_2 and SO_2, NaI gives purple I_2, H_2S and a yellow solid – the reducing power rises down the group.

Exam tips

- Halogens get **less reactive down** the group (harder to gain an electron); oxidising power decreases.
- **Displacement**: a more reactive halogen displaces a less reactive halide – state the colour change.
- Test halide ions with $AgNO_3$: white (Cl^-), cream (Br^-), yellow (I^-), then confirm with dilute/concentrated ammonia.
- Chlorine with water and with cold NaOH are **disproportionation** – show the oxidation-number changes.

3 Recap

Worked example – halogen displacement

Chlorine water is added to potassium bromide solution. State what is seen and give the ionic equation.

- Cl_2 is a stronger oxidising agent than Br_2, so it takes the electrons.
- $Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$
- Seen: the solution turns orange as Br_2 forms.
- Cl_2 is reduced ($0 \rightarrow -1$); Br^- is oxidised ($-1 \rightarrow 0$).

A halogen displaces any halide below it. Oxidising power falls down the group: $Cl_2 > Br_2 > I_2$.

Topic 11 – key takeaways

1. **Volatility**
   falls down; gas to liquid to solid
2. **Redox trends**
   oxidising power down; reducing power up
3. **Halide test**
   AgCl white, AgBr cream, AgI yellow
4. **Chlorine**
   disproportionation with NaOH; purifies water

Check yourself

1. Which way does oxidising power change down Group 17?
2. Colour of the AgI precipitate?
3. Which halide is oxidised to I_2 by conc. H_2SO_4?
4. What type of reaction is Cl_2 with NaOH?

Answers **1.** decreases **2.** yellow **3.** iodide (I^-) **4.** disproportionation