Cambridge (CIE) A Level Chemistry

Your notes

Some Reactions of the Halide Ions

Contents

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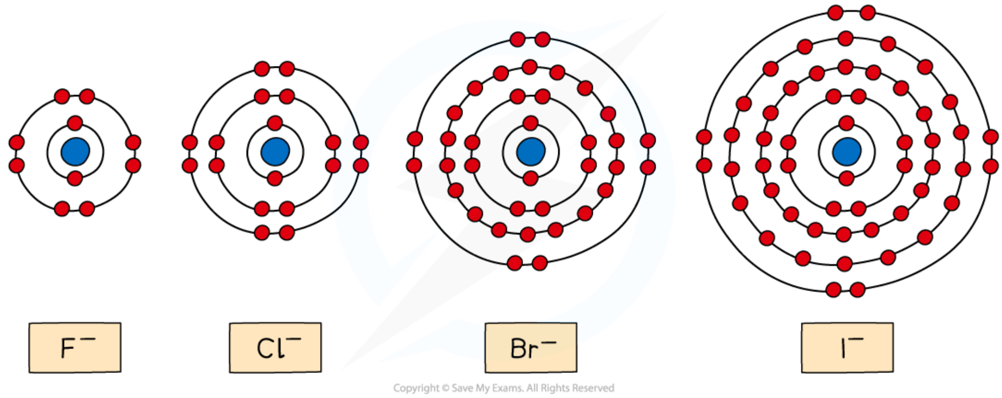
Halide Ions: Reducing Agents

- Halide ions can also act as **reducing agents** and donate electrons to another atom
- The halide ions themselves get **oxidised** and lose electrons
- The **reducing power** of the halide ions **increases** going down the group
- This trend can be explained by looking at the ionic radii of the halides' ions

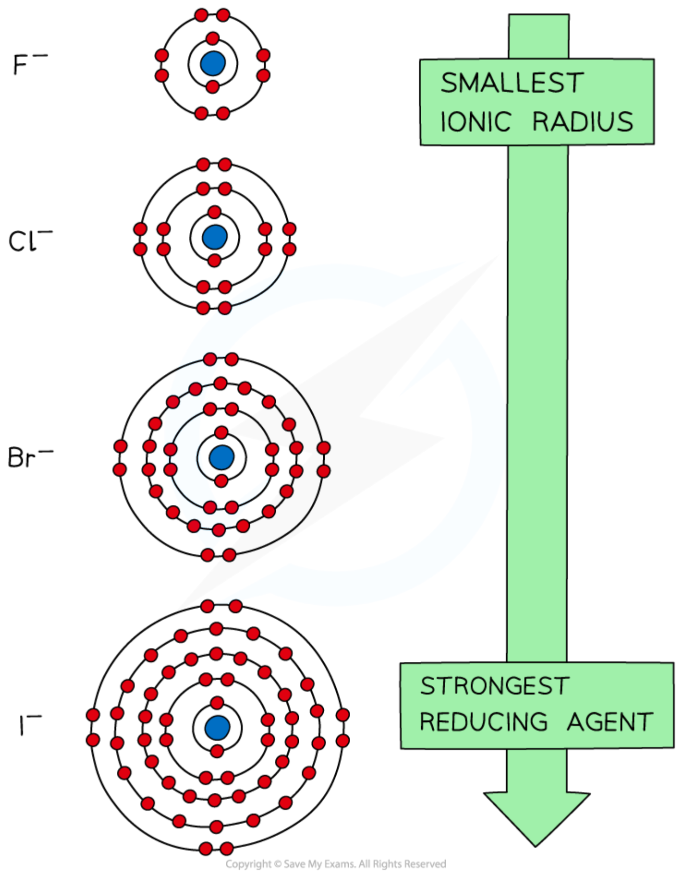
The ionic radii of the halide ions



The diagram shows that going down the group the ionic radii of the halogens increases

- Going down the group, the halide ions become **larger**
- The outermost electrons get further away from the nucleus
- The outermost electrons also experience more **shielding** by inner electrons
- As a result of this, the outermost electrons are held **less tightly** to the positively charged nucleus
- Therefore, the halide ions lose electrons more easily going down the group and their **reducing power** increases

Linking the ionic radius to the reducing power of the halide ions



The reducing power of the halide ions increases going down the group

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Examiner Tips and Tricks

The **ionic radius** is a measure of the size of an atom's **ion**

Reactions of Halide Ions

Silver ions & ammonia

- Halide ions can be identified in an **unknown solution** by dissolving the solution in **nitric acid** and then adding a **silver nitrate solution** followed by **ammonia** solution
- The halide ions will react with the silver nitrate solution as follows:

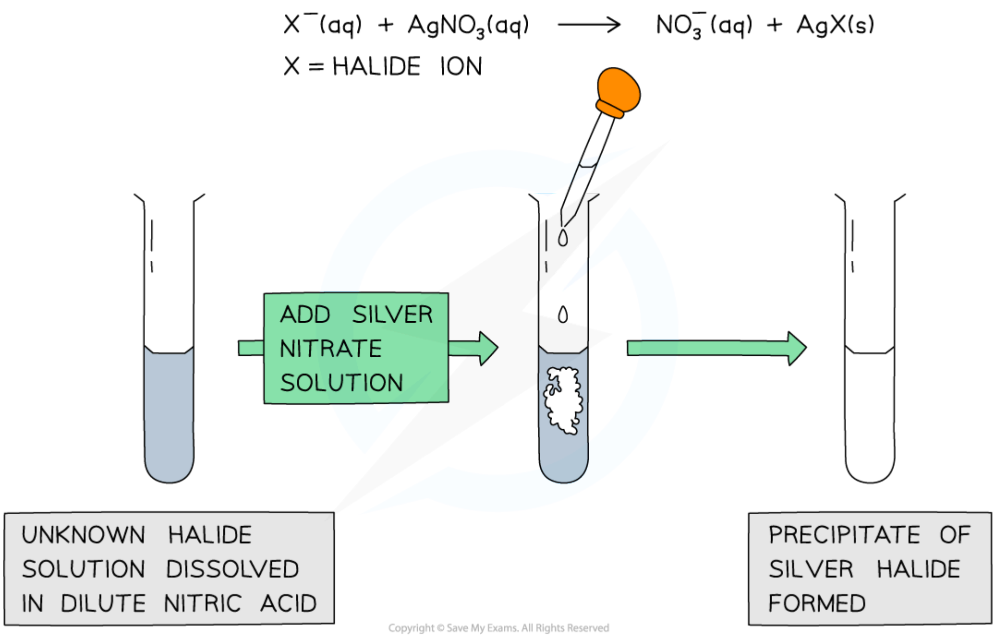
General equation: $AgNO_3 (aq) + X^- (aq) \rightarrow AgX (s) + NO_3^- (aq)$

Ionic equation: $Ag^+ (aq) + X^- (aq) \rightarrow AgX (s)$

- X^- is the halide ion in both equations
- If the unknown solution contains halide ions, then a **precipitate** of the **silver halide** will be formed (AgX)

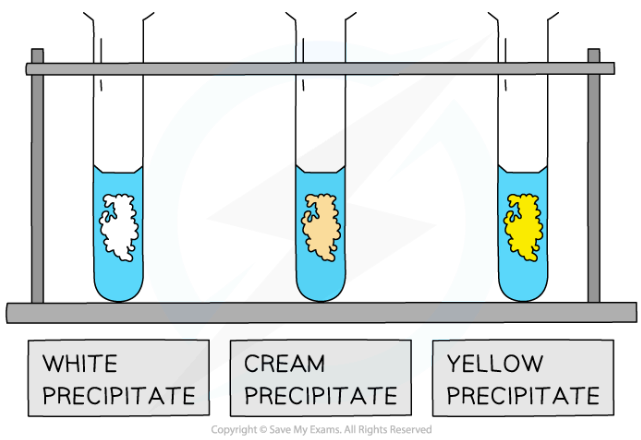
Testing for halide ions

1. Add the halide solution to a clean test tube using a pipette
2. Add a few drops of **nitric acid**
3. Add a few drops of **silver nitrate solution**



A silver halide precipitate is formed upon the addition of silver nitrate solution to halide ion solution

4. Observe the formation of a coloured precipitate:



The white, cream and yellow precipitates formed when halide ions react with silver nitrate solution

- Each precipitate is associated with a specific halide ion:
  - A white precipitate of AgCl forms if chloride ions are present

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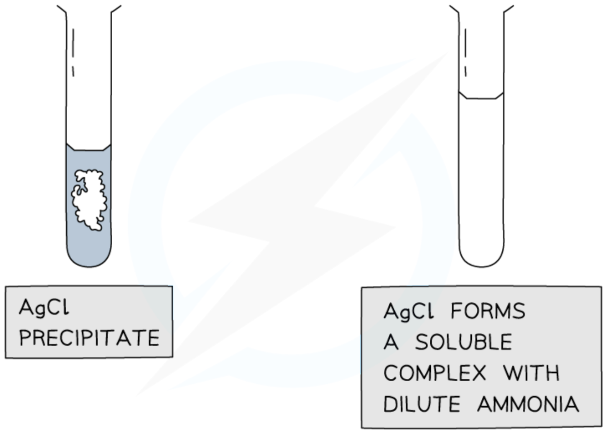
- A cream precipitate of AgBr forms if bromide ions are present
- A yellow precipitate of AgI forms if iodide ions are present

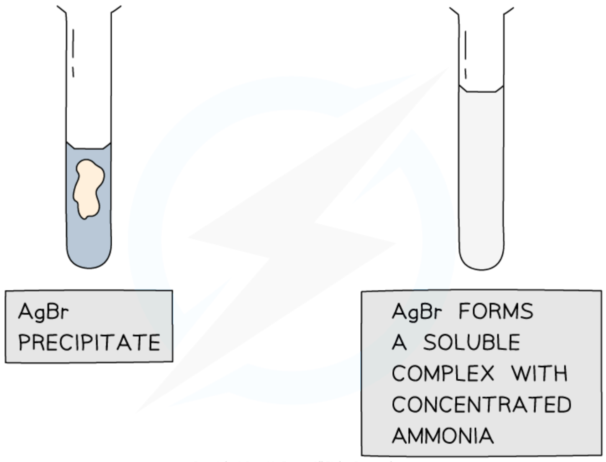
Adding ammonia after the halide ion test

- The silver halide precipitates can look similar
- So, an additional test using ammonia solution can confirm their identity

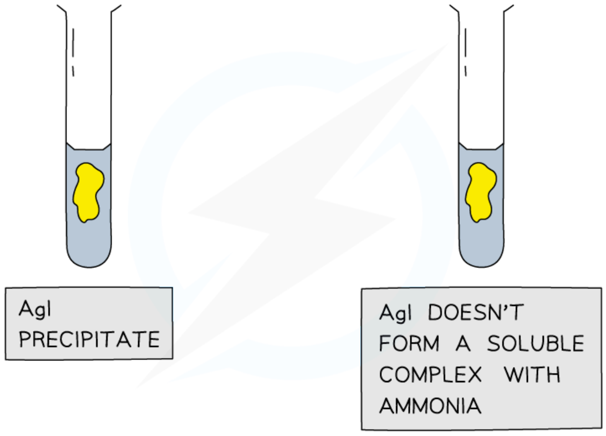
1. Add **dilute ammonia** solution dropwise to the silver halide precipitate
    - If the precipitate dissolves, the halide is **chloride** (AgCl)



2. If the precipitate does not dissolve, add **concentrated ammonia**
    - If the precipitate now dissolves, the halide is **bromide** (AgBr)



- If the precipitate still does not dissolve, the halide is **iodide** (AgI)



Reaction of halide ions with silver nitrate & ammonia solutions table

Halide ion	Colour of silver halide precipitate	Effect of adding dilute ammonia solution to the precipitate	Effect of adding concentrated ammonia solution to the precipitate
Cl^- (aq)	White	Dissolves	Dissolves
Br^- (aq)	Cream	Insoluble	Dissolves
I^- (aq)	Yellow	Insoluble	Insoluble

Concentrated sulfuric acid

- Chloride, bromide and iodide ions react with concentrated sulfuric acid to produce **toxic gases**
- These reactions should therefore be carried out in a fume cupboard
- The general reaction of the halide ions with concentrated sulfuric acid is:

General equation: $H_2SO_4 (l) + X^- (aq) \rightarrow HX (g) + HSO_4^- (aq)$

- Where X^- is the halide ion

Reaction of chloride ions with concentrated sulfuric acid

- Concentrated sulfuric acid is dropwise added to sodium chloride crystals to produce **hydrogen chloride gas**
  - The hydrogen chloride gas produced is **wet**, so it can be passed through a conical flask of concentrated sulfuric acid to produce **dry** hydrogen chloride gas

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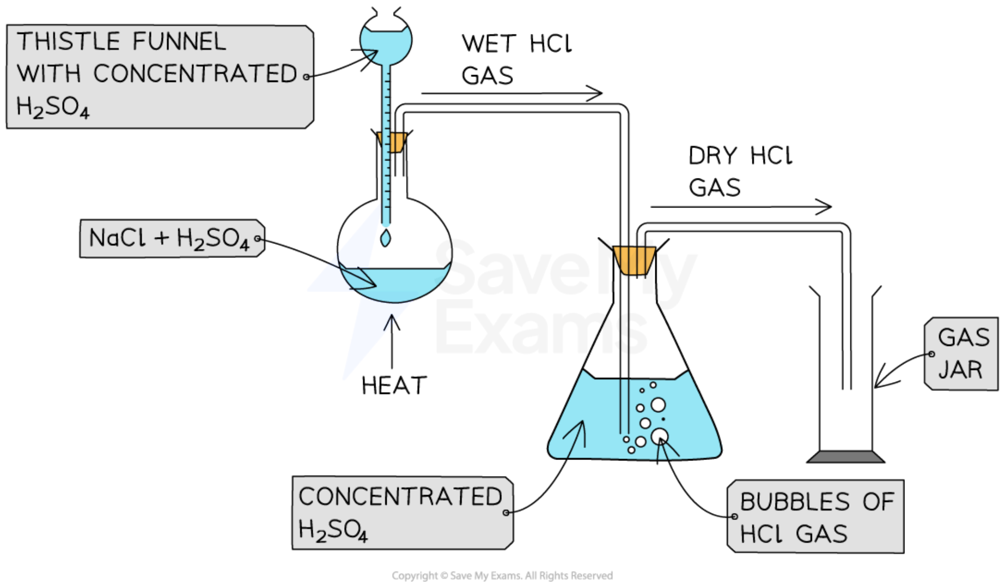
Apparatus for the reaction of sodium chloride with concentrated sulfuric acid



Sodium chloride reacts with concentrated sulfuric acid to form dense hydrogen chloride gas

- The reaction that takes place is:

$$H_2SO_4\,(l) + NaCl\,(s) \rightarrow HCl\,(g) + NaHSO_4\,(s)$$

- The HCl gas produced is seen as **white fumes**

Reaction of bromide ions with concentrated sulfuric acid

- The **thermal stability** of the hydrogen halides decreases down the group
- The reaction of sodium bromide and concentrated sulfuric acid is:

$$H_2SO_4\,(l) + NaBr\,(s) \rightarrow HBr\,(g) + NaHSO_4\,(s)$$

- The concentrated sulfuric acid **oxidises** HBr which decomposes into **bromine** and **water** and sulfuric acid itself is **reduced** to **sulfur dioxide gas**:

$$2HBr\,(g) + H_2SO_4\,(l) \rightarrow Br_2\,(g) + SO_2\,(g) + 2H_2O\,(l)$$

- The bromine is seen as a **reddish-brown gas**

Reaction of iodide ions with concentrated sulfuric acid

- The reaction of sodium iodide and concentrated sulfuric acid is:

$$H_2SO_4\,(l) + NaI\,(s) \rightarrow HI\,(g) + NaHSO_4\,(s)$$

- **Hydrogen iodide** decomposes the **easiest**

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- Sulfuric acid oxidises the hydrogen iodide to several extents:
- The concentrated sulfuric acid **oxidises** HI and is itself **reduced** to **sulfur dioxide gas**:

$$2HI\ (g) + H_2SO_4\ (l) \rightarrow I_2\ (g) + SO_2\ (g) + 2H_2O\ (l)$$

- Iodine is seen as a violet/purple vapour
- The concentrated sulfuric acid **oxidises** HI and is itself **reduced** to **sulfur**:

$$6HI\ (g) + H_2SO_4\ (l) \rightarrow 3I_2\ (g) + S\ (s) + 4H_2O\ (l)$$

- Sulfur is seen as a **yellow solid**
- The concentrated sulfuric acid **oxidises** HI and is itself **reduced** to **hydrogen sulfide**:

$$8HI\ (g) + H_2SO_4\ (l) \rightarrow 4I_2\ (g) + H_2S\ (s) + 4H_2O\ (l)$$

- Hydrogen sulfide has a **strong smell of bad eggs**

Halide ion reactions with concentrated sulfuric acid table

Halide ion	Reaction with concentrated sulfuric acid	Observations
Cl^- (aq)	H_2SO_4 (aq) + NaCl (s) → HCl (g) + $NaHSO_4$ (aq)	White fumes of HCl gas
Br^- (aq)	H_2SO_4 (aq) + NaBr (s) → HBr (g) + $NaHSO_4$ (aq) 2HBr (g) + H_2SO_4 (l) → Br_2 (g) + SO_2 (g) + $2H_2O$ (l)	Reddish brown Br_2 gas
I^- (aq)	H_2SO_4 (aq) + NaI (s) → HI (g) + $NaHSO_4$ (aq) H_2SO_4 (aq) + 2HI (s) → I_2 (g) + SO_2 (g) + $2H_2O$ (l) H_2SO_4 (aq) + 6HI (s) → $3I_2$ (g) + S (s) + $4H_2O$ (l) H_2SO_4 (aq) + 8HI (s) → $4I_2$ (g) + H_2S (s) + $4H_2O$ (l)	Violet / purple I_2 vapour Yellow solid of S Strong, bad (egg) smell of H_2S

Examiner Tips and Tricks

It gets easier to oxidise the hydrogen halides as you descend Group 17: the halides become stronger **reducing agents**