Cambridge (CIE) AS Chemistry

Your notes

The Chemical Properties of the Halogen Elements & the Hydrogen Halides

Contents

* Chemical Properties of the Halogens & Hydrogen Halides

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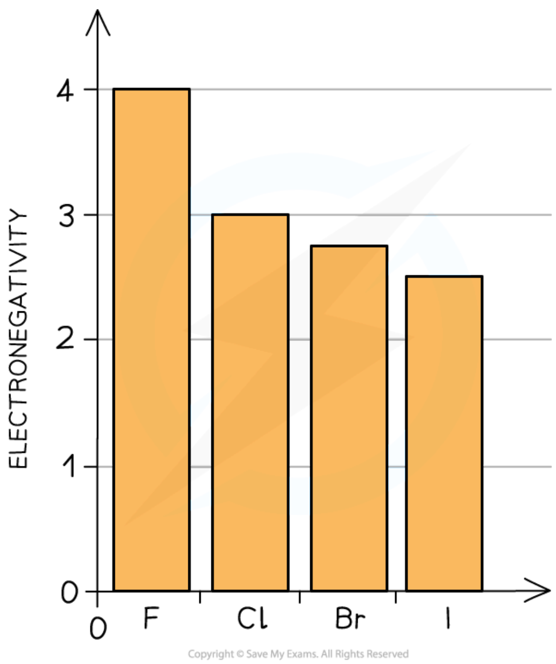
Group 17: Oxidising Agents

- Halogens react with metals by accepting an electron from the metal atom to become an ion with 1– charge, e.g.

$$Ca\,(s) + Cl_2\,(g) \rightarrow Ca^{2+}\,(Cl^-)_2\,(s)$$

- Halogens are therefore **oxidising agents**:
  - Halogens **oxidise** the metal by removing an electron from the metal (the oxidation number of the metal increases)
  - Halogens become **reduced** as they gain an extra electron from the metal atom (the oxidation number of the halogen decreases)
- The **oxidising power** of the halogens **decreases** going **down the group** (the halogens get less reactive)
- This can be explained by looking at their electronegativities:

Graph of Halogen electronegativity

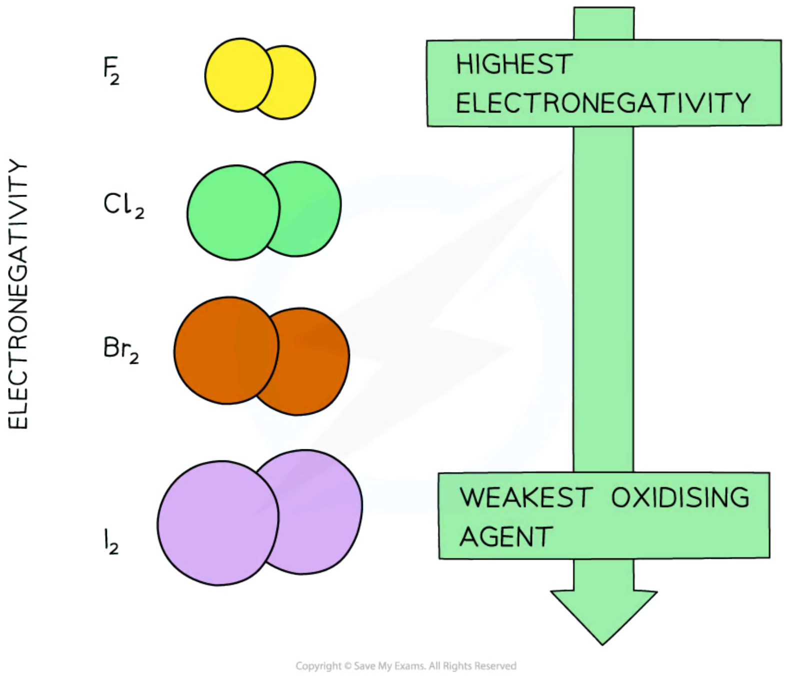


The electronegativity of the halogens decreases going down the group

- The **electronegativity** of an atom refers to how strongly it attracts electrons towards itself in a covalent bond
- The decrease in electronegativity is linked to the size of the halogens

- Going down the group, the atomic radii of the elements increase which means that the outer shells get further away from the nucleus
- An 'incoming' electron will therefore experience more **shielding** from the attraction of the positive nuclear charge
- The halogens' ability to accept an electron (their **oxidising power**) therefore decreases going down the group

Trend in Halogen electronegativity



With increasing atomic size of the halogens (going down the group) their electronegativity, and therefore oxidising power, decreases

- The reactivity of halogens is also shown by their **displacement reactions** with other halide ions in solutions
- A **more reactive** halogen can displace a **less reactive** halogen from a halide solution of the less reactive halogen
  - E.g. The addition of chlorine water to a solution of bromine water:

$$Cl_2\,(aq) + 2NaBr\,(aq) \rightarrow 2NaCl\,(aq) + Br_2\,(aq)$$

- The chlorine has displaced the bromine from the solution as it is more reactive which can be summarised in the following ionic equation:

$$Cl_2\,(aq) + 2Br^-\,(aq) \rightarrow 2Cl^-\,(aq) + Br_2\,(aq)$$

Group 17: Reaction with Hydrogen

- Halogens react with hydrogen gas to form **hydrogen halides**

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- Due to the decrease in reactivity of the halogens going down the group, the reactions between halogen and hydrogen gas become less vigorous
- The table below shows a summary of the reaction between halogen and hydrogen gas

Reaction between halogen & hydrogen gas table

Chemical equation	Observations
$H_2(g) + F_2(g) \rightarrow 2HF(g)$	Reacts explosively, even in cool / dark conditions
$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$	Reacts explosively in sunlight
$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$	Reacts slowly on heating
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$	Forms an equilibrium mixture on heating

Thermal Stability of the Hydrogen Halides

- **Thermal stability** refers to how well a substance can resist breaking down when heated
  - A substance that is thermally stable will break down at high temperatures
- The hydrogen halides formed from the reaction of halogen and hydrogen gas decrease in **thermal stability** going down the group
- The decrease in thermal stability can be explained by looking at the bond energies of the hydrogen-halogen bond
  - Going down the group, the atomic radius of the halogens increases
  - The overlap of its outer shell with a hydrogen atom therefore gives a longer bond length
  - The longer the bond, the weaker it is, and the less energy required to break it
- As the bonds get weaker, the hydrogen halogens become less stable to heat going down the group

Trend in thermal stability of the hydrogen halides

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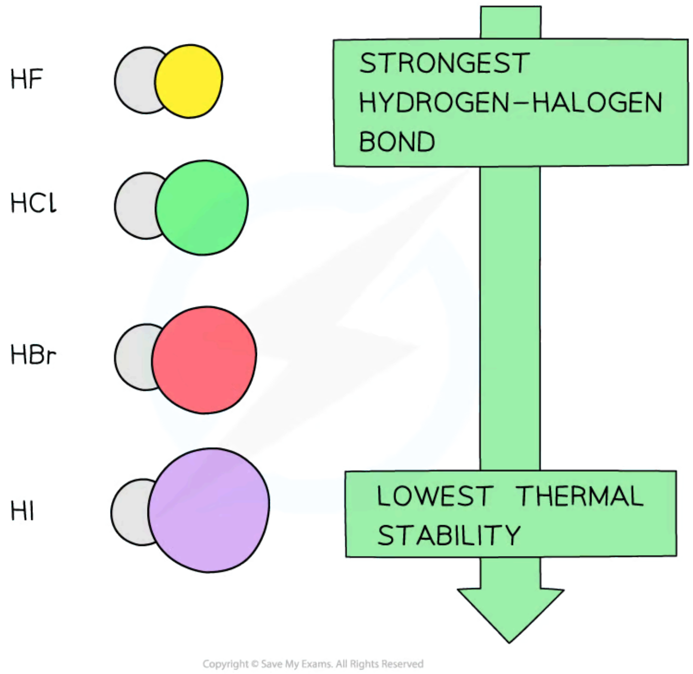

The thermal stability of the hydrogen halide decreases going down the group as their bonds become weaker due to the increased atomic radius of the halogens

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