Group 7 – The Halogens

Physical Properties

Chlorine is a pale green gas, bromine is a dark red liquid and iodine is a shiny dark grey solid. Volatility decreases down the group due to increasing induced dipole-dipole interactions. See bonding notes

Redox Reactions and trends in reactivity

They all have an outer shell s^2p^5 electron configuration and gain one electron in many redox reactions to form 1– ions

Displacement reactions

Any halogen can displace another lower in the group, giving a colour change. Chlorine displaces both bromine and iodine. Bromine displaces iodine. The reaction is carried out using water as the solvent. An organic solvent is then added to dissolve the halogen present; this allows the colour of the halogen to be seen more easily since they are often very pale when dissolved in water.

$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq)$

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

$Br_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Br^-(aq)$

Colours of Halogen Solutions

Halogen	**Cl_2**	Br_2	**I_2**
Colour in water	**Pale green**	**Orange**	**Brown**
Colour in cyclohexane	**Pale green**	**Orange**	**Purple**

Remember all halide ions (Cl^-, Br^- and I^-) are colourless in solution.

Oxidising power, i.e reactivity, decreases down the group because an electron can be captured less easily as atomic radius increases and attraction between nucleus and outer electron decreases due to increased shielding.

Disproportionation Reactions

In most redox reactions the oxidation number of one element rises and the oxidation number of another falls. In a disproportionation reaction it is the same element which both rises and falls in oxidation number.

Examples:

1. **Water purification**

Chlorine is used to sterilise drinking water to prevent life-threatening diseases.
Water and chlorine form hydrochloric acid and chloric (I) acid in a disproportionation reaction.
i.e chlorine atoms are both oxidised and reduced.

$$\underset{0}{Cl_2} + H_2O \rightarrow \underset{-1}{HCl} + \underset{+1}{HClO}$$

2. **Formation of bleach**

Chlorine reacts with cold, dilute aqueous sodium hydroxide to form bleach, a solution containing sodium chloride and sodium chlorate(I). This is also a disproportionation reaction.

$$\underset{0}{Cl_2} + 2NaOH \rightarrow \underset{-1}{NaCl} + \underset{+1}{NaClO} + H_2O$$

Although chlorine has beneficial uses in the use of killing bacteria in water supply and thus saving many lives, it also has associated risks since chlorine gas is highly toxic and it can form chlorinated hydrocarbons in the water supply that have been linked to causing cancer.

<u>Characteristic reactions of halide ions</u>

Add dilute nitric acid and **aqueous silver nitrate** to the unknown halide solution followed by aqueous ammonia.

Chloride ions form a **white precipitate of silver chloride** that dissolves in dilute aqueous ammonia.

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

Bromide ions form a **cream ppt of silver bromide** that dissolves in conc aqueous ammonia.

$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$

Iodide ions form a **yellow ppt of silver iodide** that does not dissolve in conc aqueous ammonia.

$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$