Interhalogen

The halogens react with each other to form interhalogen compounds.

The general formula of most interhalogen compounds is $XY_n$, where $n = 1, 3, 5$ or $7$, and $X$ is the less electronegative of the two halogens. They are all prone to hydrolysis, and ionise to give rise to polyatomic ions.

Diatomic interhalogens

The interhalogens of form $XY$ have physical properties intermediate between those of the two parent halogens. The covalent bond between the two atoms has some ionic character, the less electronegative element, $X$, being oxidised and having a partial positive charge. Most combinations of $F$, $Cl$, $Br$ and $I$ are known, but not all are stable.

Chlorine monofluoride (ClF)
The lightest interhalogen compound, ClF is a colorless gas with a normal boiling point of $-100 \degree C$.

Bromine monofluoride (BrF)
BrF has not been obtained pure — it dissociates into the trifluoride and free bromine.

Iodine monofluoride (IF)
IF is unstable and decomposes at 0 $\degree C$, disproportionating into elemental iodine and iodine pentafluoride.

Bromine monochloride (BrCl)
A red-brown gas with a boiling point of 5 $\degree C$.

Iodine monochloride (ICl)
Red transparent crystals which melt at 27.2 $\degree C$ to form a choking brownish liquid (similar in appearance and weight to bromine). It reacts with HCl to form the strong acid HICl$_2$.$\text{BrCl}$ has the same molecular shape as chlorine trifluoride.

Iodine monobromide (IBr)
Made by direct combination of the elements to form a dark red crystalline solid. It melts at 42 $\degree C$ and boils at 116 $\degree C$ to form a partially dissociated vapour.

Tetra-atomic interhalogens

- **Chlorine trifluoride** (ClF$_3$) is a colourless gas which condenses to a green liquid, and freezes to a white solid. It is made by reacting chlorine with an excess of fluorine at 250 $\degree C$ in a nickel tube. It reacts more violently than fluorine, often explosively. The molecule is planar and T-shaped. It is used in the manufacture of uranium hexafluoride.

- **Bromine trifluoride** (BrF$_3$) is a yellow green liquid which conducts electricity — it ionises to form [BrF$_3^+$] + [BrF$_4^-$. It reacts with many metals and metal oxides to form similar ionised entities; with some others it forms the metal fluoride plus free bromine and oxygen. It is used in organic chemistry as a fluorinating agent. It has the same molecular shape as chlorine trifluoride.

- **Iodine trifluoride** (IF$_3$) is a yellow solid which decomposes above $-28 \degree C$. It can be synthesised from the elements, but care must be taken to avoid the formation of IF$_5$. F$_2$ attacks I$_2$ to yield IF$_3$ at $-45 \degree C$ in CCl$_3$F. Alternatively, at low temperatures, the fluorination reaction I$_2$ + 3XeF$_2$ $\rightarrow$ 2IF$_3$ + 3Xe can be used. Not much is known about iodine trifluoride as it is so unstable.

- **Iodine trichloride** (ICl$_3$) forms lemon yellow crystals which can be melted under pressure to a brown liquid. It can be made from the elements at low temperature, or from iodine pentoxide and hydrogen chloride. It reacts with many metal chlorides to form tetrachloriodides, and hydrolysates in water. The molecule is a planar dimer, with each iodine atom surrounded by four chlorine atoms.
Hexa-atomic interhalogens

- **Chlorine pentafluoride** (ClF$_5$) is a colourless gas, made by reacting chlorine trifluoride with fluorine at high temperatures and high pressures. It reacts violently with water and most metals and nonmetals.
- **Bromine pentafluoride** (BrF$_5$) is a colourless fuming liquid, made by reacting bromine trifluoride with fluorine at 200° C. It is physically stable, but reacts violently with water and most metals and nonmetals.
- **Iodine pentafluoride** (IF$_5$) is a colourless liquid, made by reacting iodine pentoxide with fluorine, or iodine with silver fluoride. It is highly reactive, even slowly with glass. It reacts with elements, oxides and carbon halides. The molecule has the form of a tetragonal pyramid.

Octa-atomic interhalogens

- **Iodine heptafluoride** (IF$_7$) is a colourless gas. It is made by reacting the pentafluoride with fluorine. IF$_7$ is chemically inert, having no lone pair of electrons in the valency shell; in this it resembles sulfur hexafluoride. The molecule is a pentagonal bipyramid. This compound is the only interhalogen compound possible where the larger atom is carrying seven of the smaller atoms.
- All attempts to form bromine heptafluoride have met with failure; instead, bromine pentafluoride and fluorine gas are produced.

Summary of known interhalogens

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References

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