INTERHALOGEN COMPOUNDS
An interhalogen compound is a molecule which contains two or more different halogen atoms (fluorine, chlorine, bromine, iodine, or astatine) and no atoms of elements from any other group. Most interhalogen compounds known are binary (composed of only two distinct elements)

The common interhalogen compounds include Chlorine monofluoride, bromine trifluoride, iodine pentafluoride, iodine heptafluoride, etc.
Interhalogen compounds into four types, depending on the number of atoms in the particle. They are as follows:

\[
\begin{align*}
XY \\
XY_3 \\
XY_5 \\
XY_7
\end{align*}
\]

\(X\) is the bigger (or) less electronegative halogen. \(Y\) represents the smaller (or) more electronegative halogen.
<table>
<thead>
<tr>
<th>XY</th>
<th>XY$_3$</th>
<th>XY$_5$</th>
<th>XY$_7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClF(g)$^a$</td>
<td>ClF$_3$(g)</td>
<td>ClF$_5$(g)</td>
<td></td>
</tr>
<tr>
<td>BrF(g)</td>
<td>BrF$_3$(l)</td>
<td>BrF$_5$(l)</td>
<td></td>
</tr>
<tr>
<td>BrCl(g)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICl(s)</td>
<td>ICl$_3$(s)</td>
<td>IF$_5$(l)</td>
<td>IF$_7$(g)</td>
</tr>
<tr>
<td>IBr(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All are of the type XX$'_n$ where $n =$ odd nos. $X'$ is always the lighter halogen since the smaller halogen $X'$ are bonded around the larger $X$. As the ratio of the radius of $X$ to that of $X'$ increases, $n$ also increases.
<table>
<thead>
<tr>
<th>Compound</th>
<th>CIF</th>
<th>BrF</th>
<th>BrCl</th>
<th>ICI</th>
<th>IBr</th>
<th>ClF₃</th>
<th>BrF₃</th>
<th>IF₃</th>
<th>I₂Cl₆</th>
<th>ClF₅</th>
<th>BrF₅</th>
<th>IF₅</th>
<th>IF₇</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance at 298K</td>
<td>Colorless gas</td>
<td>Pale brown gas</td>
<td>impure</td>
<td>Red solid</td>
<td>Black solid</td>
<td>Colorless gas</td>
<td>Yellow liquid</td>
<td>Yellow solid</td>
<td>Orange solid</td>
<td>Colorless gas</td>
<td>Colorless liquid</td>
<td>Colorless liquid</td>
<td>Colorless gas</td>
</tr>
<tr>
<td>Stereochemistry</td>
<td>linear</td>
<td>linear</td>
<td>linear</td>
<td>linear</td>
<td>linear</td>
<td>T-shaped</td>
<td>T-shaped</td>
<td>T-shaped</td>
<td>planar</td>
<td>square-based pyramid</td>
<td>square-based pyramid</td>
<td>square-based pyramid</td>
<td>pentagonal bipyramid</td>
</tr>
<tr>
<td>Melting point /K</td>
<td>117</td>
<td>173</td>
<td>146</td>
<td>300(a)</td>
<td>313</td>
<td>197</td>
<td>282</td>
<td>245 (dec)</td>
<td>337 (sub)</td>
<td>170</td>
<td>212.5</td>
<td>282.5</td>
<td>278 (sub)</td>
</tr>
<tr>
<td>Boiling point /K</td>
<td>173</td>
<td>~293</td>
<td>~278</td>
<td>~373</td>
<td>389</td>
<td>285</td>
<td>399</td>
<td>-</td>
<td>-</td>
<td>260</td>
<td>314</td>
<td>373</td>
<td>-</td>
</tr>
<tr>
<td>ΔH°(298 K)/kJ mol⁻¹</td>
<td>-50.3</td>
<td>-58.5</td>
<td>14.6</td>
<td>-23.8</td>
<td>-10.5</td>
<td>-163.2</td>
<td>-300.8</td>
<td>-500</td>
<td>-93.9</td>
<td>-255</td>
<td>-458.6</td>
<td>-864.8</td>
<td>-962</td>
</tr>
<tr>
<td>Dipole moment for gas-phase molecule /D</td>
<td>0.89</td>
<td>1.42</td>
<td>0.52</td>
<td>1.24</td>
<td>0.73</td>
<td>0.6</td>
<td>1.19</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>1.51</td>
<td>2.18</td>
<td>0</td>
</tr>
<tr>
<td>Bond distances in gas-phase molecules except for IF₅ and I₂Cl₆ / pm</td>
<td>163</td>
<td>176</td>
<td>214</td>
<td>232</td>
<td>248.5</td>
<td>160 (eq), 170 (ax)</td>
<td>172 (eq), 181 (ax)</td>
<td>187 (eq), 198 (ax)</td>
<td>238 (terminal)</td>
<td>268 (bridge)</td>
<td>172 (basal), 178 (apical)</td>
<td>187 (basal), 185 (apical)</td>
<td>186 (eq), 179 (ax)</td>
</tr>
</tbody>
</table>
Properties of Interhalogen Compounds

• We can find Interhalogen compounds in vapour, solid or fluid state.

• A lot of these compounds are unstable solids or fluids at 298K. A few other compounds are gases as well. As an example, chlorine monofluoride is a gas. On the other hand, bromine trifluoride and iodine trifluoride are solid and liquid respectively.

• These compounds are covalent in nature.

• These interhalogen compounds are diamagnetic in nature. This is because they have bond pairs and lone pairs.

• Interhalogen compounds are very reactive. One exception to this is fluorine. This is because the A-X bond in interhalogens is much weaker than the X-X bond in halogens, except for the F-F bond.

• We can use the VSEPR theory to explain the unique structure of these interhalogens. In chlorine trifluoride, the central atom is that of chlorine. It has seven electrons in its outermost valence shell. Three of these electrons form three bond pairs with three fluorine molecules leaving four electrons.
PREPARATION

We can manufacture these interhalogen compounds by **two main methods**.

One of them includes the **direct mixing of halogens** and the other includes a **reaction of halogens with the lower Interhalogen compounds**.

The halogen atoms react to form an interhalogen compound. One example includes the reaction when a volume of chlorine reacts with an equal volume of fluorine at 473K. The resultant product is chlorine monofluoride.

In other cases, a halogen atom acts with another lower interhalogen to form an interhalogen compound. For example, fluorine reacts with iodine pentafluoride at 543K. This gives rise to the compound of Iodine Heptafluoride.
\[ \text{Cl}_2 + \text{F}_2 \xrightarrow{437 \, K} 2\text{ClF}; \quad (\text{equal volume}) \]

\[ \text{Cl}_2 + 3\text{F}_2 \xrightarrow{573 \, K} 2\text{ClF}_3; \quad (\text{excess}) \]

\[ \text{I}_2 + \text{Cl}_2 \rightarrow 2\text{ICl}; \quad (\text{equimolar}) \]

\[ \text{I}_2 + 3\text{Cl}_2 \rightarrow 2\text{ICl}_3; \quad (\text{excess}) \]

\[ \text{Br}_2 + 3\text{F}_2 \rightarrow 2\text{BrF}_3 \quad (\text{diluted with water}) \]

\[ \text{Br}_2 + 5\text{F}_2 \rightarrow 2\text{BrF}_5; \quad (\text{excess}) \]
Iodine mono chloride $\text{ICl}$ is formed by passing chlorine over solid iodine at temperature below $0^\circ\text{C}$.

$$\text{I}_2 + \text{Cl}_2 \rightarrow 2\text{ICl}$$

- It is a red-brown chemical compound.
- Because of the difference in the electronegativity of iodine and chlorine, $\text{ICl}$ is highly polar; $\text{I}^+\text{Cl}^-$.
Bromine trifluoride... \( \text{BrF}_3 \)

- It is obtained by mixing bromine vapor and fluorine in a stream of nitrogen at 20°C.

\[
\text{Br}_2 + 3\text{F}_2 \rightarrow 2\text{BrF}_3
\]

It is a straw-colored liquid with a pungent odor.

It is a powerful **fluorinating agent**

It is used to produce **uranium hexafluoride** (\( \text{UF}_6 \)) in the processing and reprocessing of nuclear fuel.
Bromo pentafluoride ... $\text{BrF}_5$

It is pale yellow liquid

By the direct reaction of bromine with excess fluorine at temp. over 150°C

$$\text{Br}_2 + 5 \text{F}_2 \rightarrow 2 \text{BrF}_5$$

It is an extremely effective fluorinating agent, converting most uranium compounds to the hexafluoride at room temperature like $\text{BrF}_3$. 
Iodine heptafluoride...IF$_7$

- It is a colorless gas
- It is prepared by passing a mixture of iodine pentafluoride vapors and fluorine through a platinum tube at 300 °C.

$$\text{IF}_5 + \text{F}_2 \rightarrow \text{IF}_7$$

- It is a strong oxidizing agent
- Used to prepare periodic acid.
Shapes of interhalogens

ClF
linear, XY

ClF₃
T-shaped, XY₃

BrF₅
Square pyramidal, XY₅

IF₇
Pentagonal bipyramidal, XY₇
Uses of Interhalogen Compounds

• We use interhalogen compounds as non-watery solvents.

• Also, we use these compounds as a catalyst in a number of reactions.

• We use UF$_6$ in the enrichment of $^{235}$U. We can produce this by using ClF$_3$ and BrF$_3$.

\[
U(s) + 3\text{ClF}_3(l) \rightarrow \text{UF}_6(g) + 3\text{ClF}(g)
\]

• We use these compounds as fluorinating compounds.