

## Intermolecular Forces

Three types of force can operate between covalent molecules:

1. **Dispersion Forces** - also known as London Forces (named after Fritz London who first described these forces theoretically 1930) or as van der Waal's Forces (named after the person who contributed to our understanding of non-ideal gas behavior).
2. **Dipole-dipole interactions**
3. **Hydrogen bonds**

Relative strength of Intermolecular Forces:

- **Intermolecular** forces are much weaker than **intramolecular** forces (covalent bonds, ionic bonds or metallic bonds)
- Dispersion forces are the weakest intermolecular force, hydrogen bonds are the strongest

Dispersion Forces (London Forces, van der Waal's Forces)

- Very weak forces of attraction between molecules resulting from: **Temporary** dipoles occurring between two non-polar molecules
- The more electrons that are present in the molecule, the stronger the dispersion forces will be.

Dispersion forces are the only type of intermolecular force between non-polar molecules, for example, dispersion forces operate between hydrogen ( $H_2$ ) molecules, chlorine ( $Cl_2$ ) molecules, carbon dioxide ( $CO_2$ ) molecules, dinitrogen tetroxide ( $N_2O_4$ ) molecules and methane ( $CH_4$ ) molecules.

Dipole-dipole Interactions

- Occur between molecules that have **permanent** net dipoles (polar molecules), for example, between  $SCl_2$  molecules,  $PCl_3$  molecules and  $CH_3Cl$  molecules.
- The partial positive charge on one molecule is attracted to the partial negative charge on a neighboring molecule.

Hydrogen bonds

- Occur between molecules that have a permanent net dipole resulting from hydrogen being covalently bonded to either fluorine, oxygen or nitrogen. For example, water ( $H_2O$ ) molecules, ammonia ( $NH_3$ ) molecules, hydrogen fluoride ( $HF$ ) molecules
- Electrostatic attraction between these molecules will be greater than for the polar molecules that do not have hydrogen covalently bonded to either fluorine, oxygen or nitrogen (due to their high electronegativities).