Intermolecular Attractions -- Liquids and Solids

Intermolecular Forces

- **Intermolecular forces are the forces of attractions that exist between molecules**
- **The strength of these forces determine:**
  - **The state of matter: solid, liquid, or gas**
  - **The melting and boiling points of compounds**
  - **The solubilities of one substance in another.**

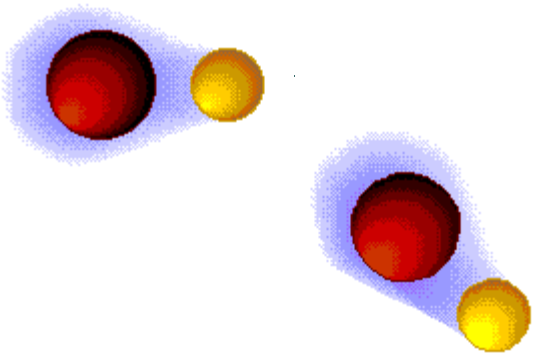
Types of Intermolecular Forces

- 4 main types of intermolecular forces

(1) London (Dispersion) Forces
(2) Dipole-Dipole Forces
(3) Ion-Dipole Forces
(4) Hydrogen Bonds

Hydrogen Bonding

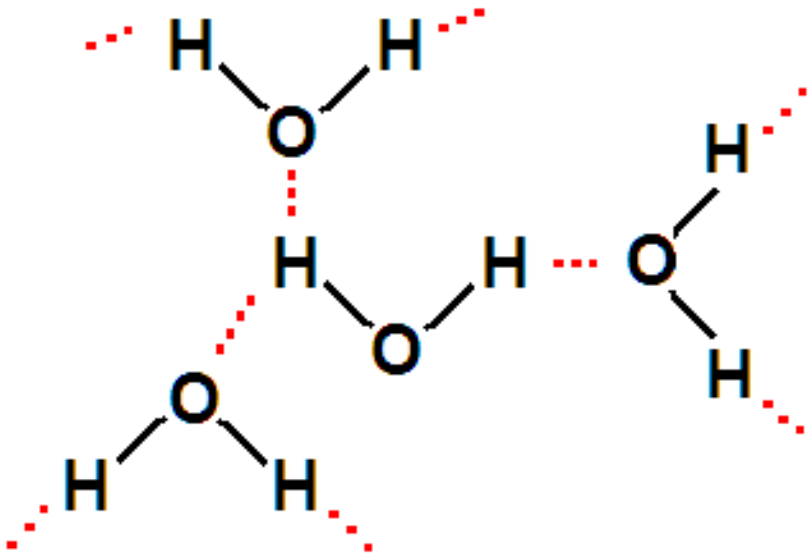
Hydrogen bonding occurs between polar covalent molecules that possess a hydrogen atom that is bonded to an extremely electronegative element; specifically - N, O, and F.



Weak attractions occur between the hydrogen atoms of one molecule and the oxygen atom of another.

Hydrogen Bonding

The weak attractions that result from hydrogen bonding cause molecules to stick together.



As a result molecules with significant hydrogen bonding have higher melting points and boiling points than they would otherwise have.

Hydrogen Bonding

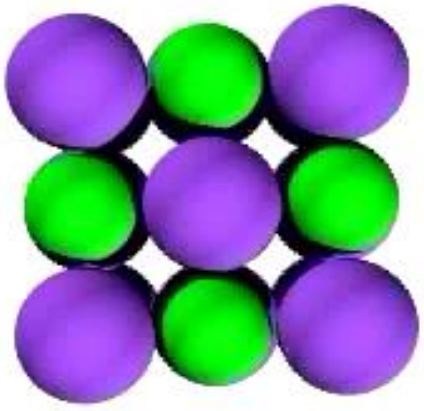
Hydrogen bonds are the strongest of all of the intermolecular forces. They are about one-tenth the strength of a covalent bond .

Because hydrogen bonds must be overcome for a substance to melt or evaporate, substances that have significant hydrogen bonding have higher than normal melting and boiling temperatures

Ion-Dipole Forces

The force which dissolves ionic compounds

A result of interactions between ions and solvent molecules



Dipole-Dipole Attractions

- **If the permanent net dipole within the polar molecules results from a covalent bond between a hydrogen atom and either fluorine, oxygen or nitrogen, the resulting intermolecular force is referred to as a hydrogen bond**
- **If this attraction occurs between other polar molecules it is referred to as a dipole to dipole interaction**

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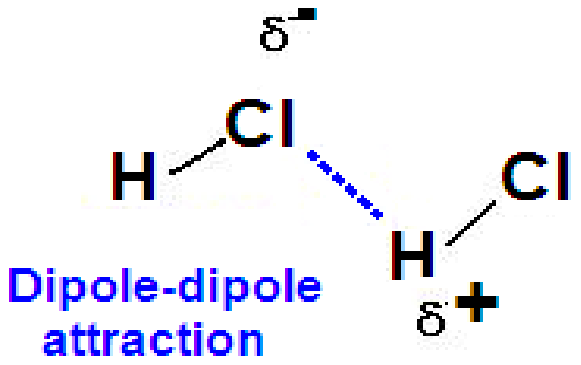
Dipole-Dipole Attractions

- **Dipole-Dipole attractions occur between molecules that have permanent net dipoles. (polar molecules),**
- **The partial positive charge on one molecule is electrostatically attracted to the partial negative charge on a neighboring molecule.**



Dipole-Dipole Attractions

- Some examples of molecules with dipole-dipole interactions include:
  - **SCl_2**
  - **PCl_3**
  - **CH_3Cl**

van der Waals Forces

van der Waals or dispersion forces are very weak forces of attraction between molecules

They result from:

1. **momentary dipoles occurring due to uneven electron distributions in neighboring molecules as they approach one another**
2. **the weak residual attraction of the nuclei in one molecule for the electrons in a neighboring molecule.**

Dispersion Forces

van der Waal's Forces are named after the person who contributed to our understanding of non-ideal gas behavior). They are also as known dispersion forces or as London Forces (named after Fritz London who first described these forces theoretically in 1930)

Dispersion Forces

- **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 that operates between non-polar molecules**
- **Dispersion forces exist between non-polar molecules such as**
  - **hydrogen (H_2)**
  - **chlorine (Cl_2)**
  - **carbon dioxide (CO_2)**
  - **methane (CH_4)**

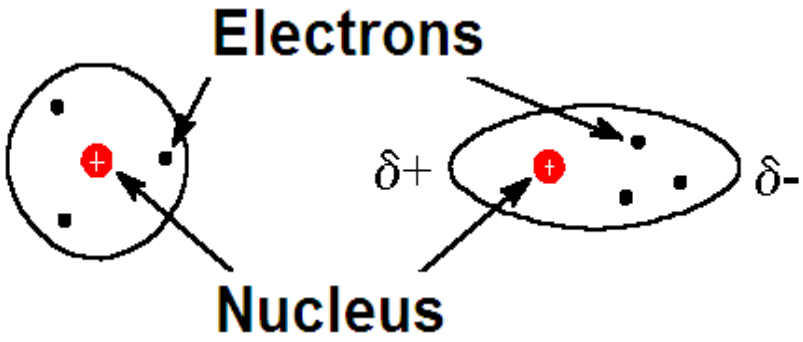
Dispersion Forces

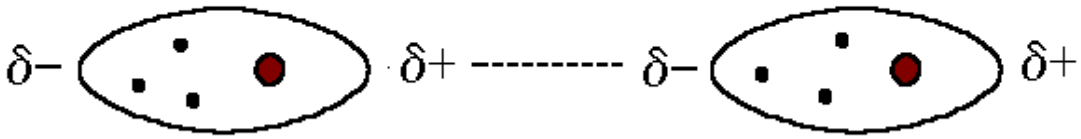
van der Waals or dispersion forces are the weakest of the intermolecular forces

They are typically only 0.1% to 1% as strong as covalent bonds between atoms in a molecule

London Dispersion Forces

The van der Waals or London dispersion force is a temporary attractive force that occurs when the electrons in two adjacent atoms occupy positions that make the atoms form temporary dipoles.

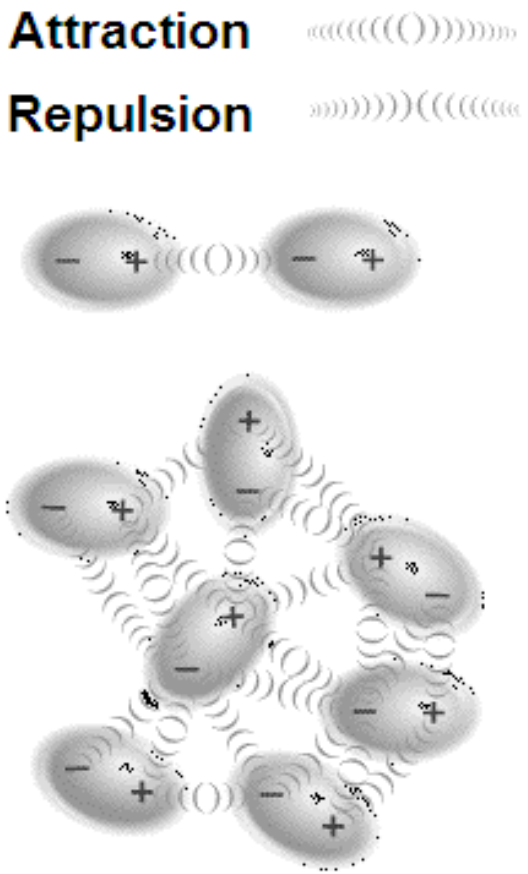




This force is sometimes called an induced dipole-induced dipole attraction.

Effects of London Dispersion Forces

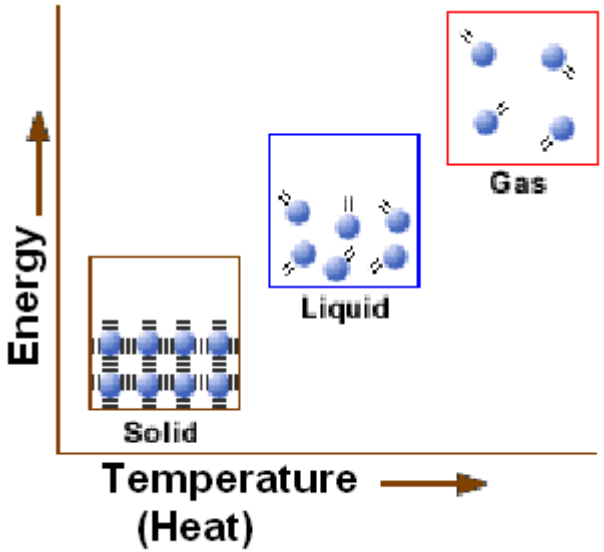
- **London forces are the attractive forces that cause non-polar substances to condense to liquids and to freeze into solids when the temperature is lowered sufficiently.**
- **Phase changes occur when molecules are sufficiently close and dispersion forces are sufficiently strong to hold molecules together**



The Liquid State

The liquid state of a material has a definite volume, but it does not have a definite shape and takes the shape of the container, unlike that of the solid state.

Unlike the gas state, a liquid does not occupy the entire volume of the container if the container volume is larger than the volume of the liquid.

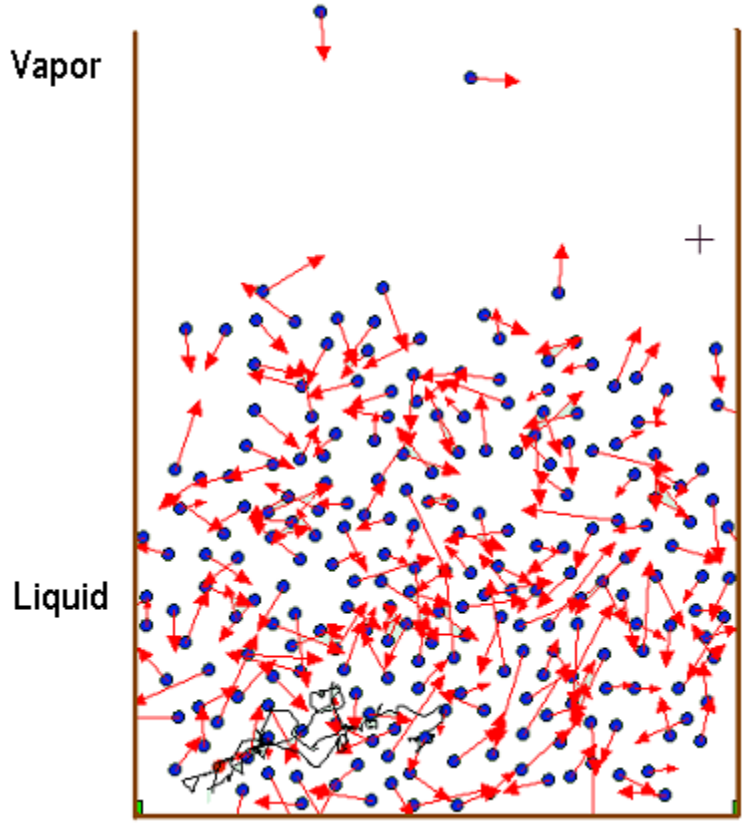


The Liquid State

At the molecular level, the arrangement of the molecules is random, unlike that of the solid state in which the molecules are regular and periodic.

Molecules are still closely packed but they can slip past each other and move around the body of the liquid.

There may be some short order intermolecular ordering or structure, however.



Solids, Liquids and Gases

The intermolecular forces between particles become stronger as particles are packed closer together and move less rapidly

Energy is required to convert from solid to liquid to gas