Lesson Overview
Intermolecular Forces

Objective: The student will be able to identify intermolecular forces based on lewis structures.

I. Intra vs. Intermolecular Forces
   A. Definition of forces
   B. Comparison and contrast

II. Intermolecular Forces
   A. Explanation of Types of IMFs
   B. Determining IMFs *in situ*
   C. Applications

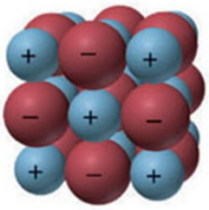
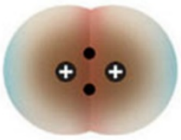
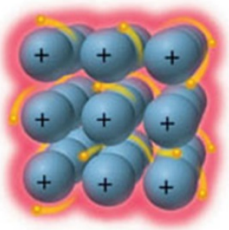
Intermolecular Forces

Definition: the forces that hold molecules together.

Intra- vs. intermolecular forces:

- Intra "inward"
  - Examples: ionic, covalent, metallic
- Inter "outward"
  - Examples: Hydrogen bonding, dipole-dipole, van der Waals.

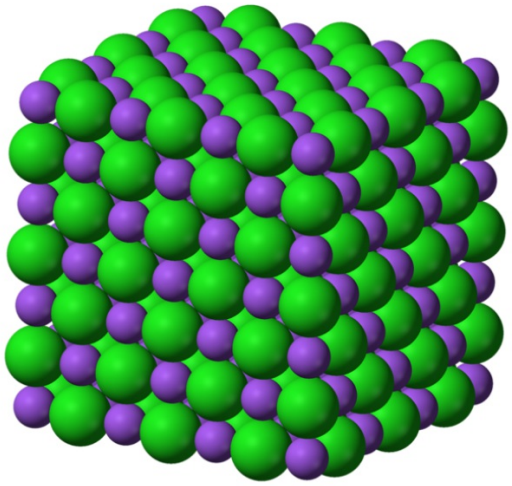
Table 12.2 Comparison of Bonding and Nonbonding (Intermolecular) Forces

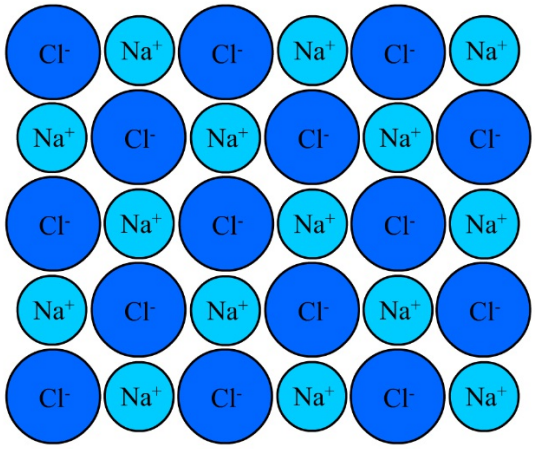
Force	Model	Basis of Attraction	Energy (kJ/mol)	Example
Bonding				
Ionic		Cation–anion	400–4000	NaCl
Covalent		Nuclei–shared e^- pair	150–1100	H—H
Metallic		Cations–delocalized electrons	75–1000	Fe

Intermolecular Forces

IMFs dominate covalent molecules

Intermolecular forces are weaker than intramolecular forces.





Determining Intermolecular Forces

non-polar + non-polar = van der Waals (london dispersion)

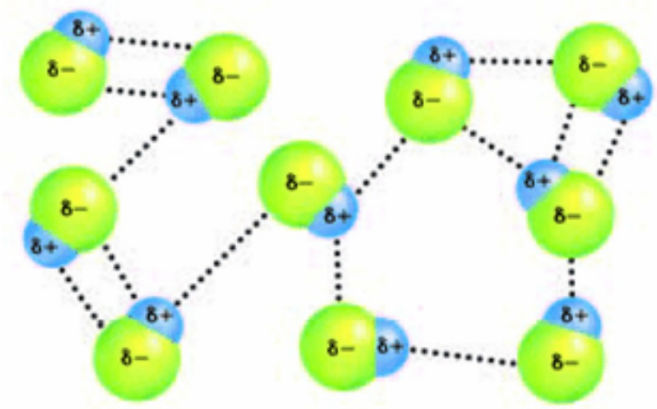
polar + polar = dipole - dipole

- **if Hydrogen is bound to F, O, N then H-interaction**

polar + non-polar = dipole-induced dipole

Dipole – Dipole Forces

- Permanent dipoles
- Attraction between polar molecules
- Stronger than London Dispersion



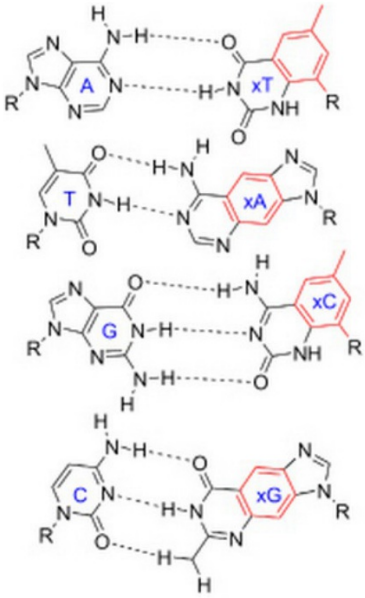
What is a dipole?

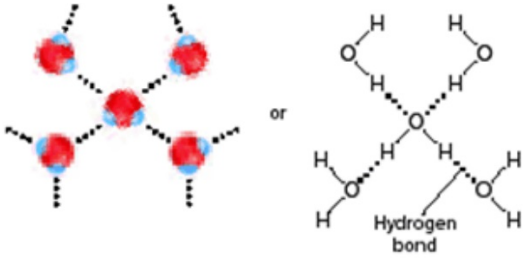
Hydrogen bonding

Occurs when hydrogen is bonded to fluorine, oxygen, nitrogen, and sulfur.

FON(S)

The strongest of the IMFs

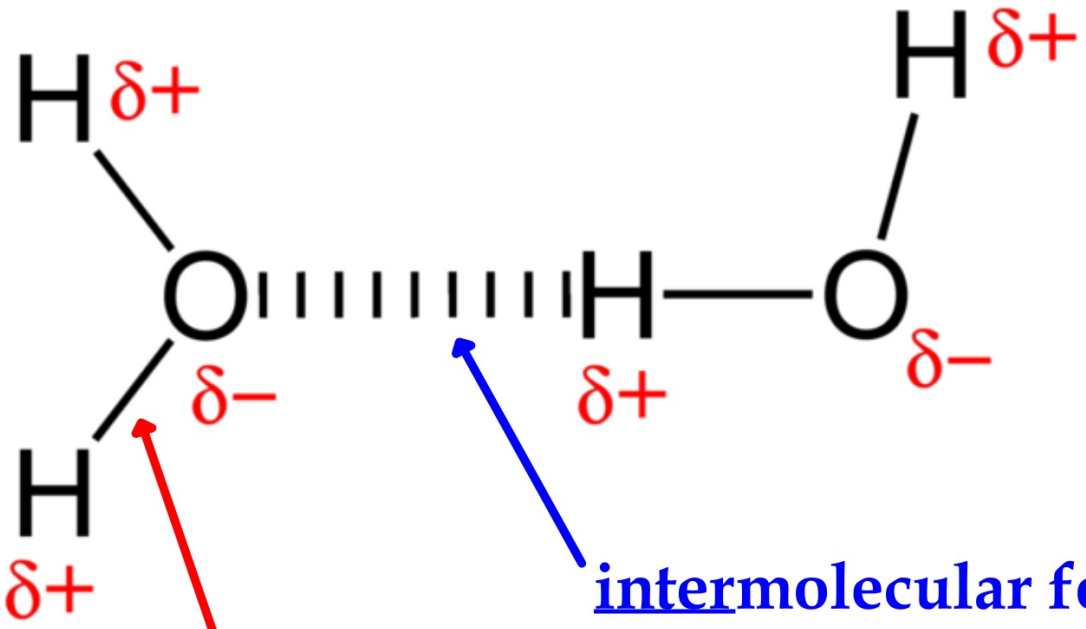




- Has many applications in biological systems.
- Cohesion and adhesion
- Protein stabilization

It is not really a bond. It is an interaction between molecules.

Hydrogen interactions

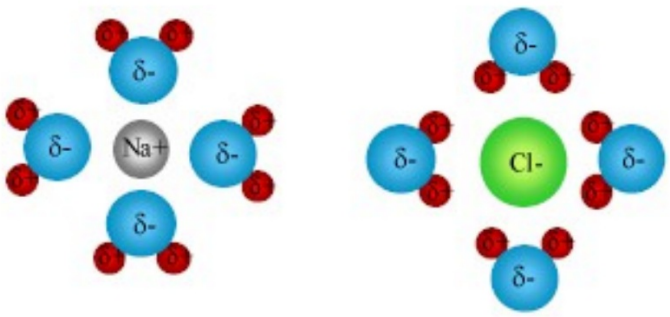


intermolecular force (hydrogen bond)

intramolecular force (covalent bond)

Ion - Dipole Forces

Occurs when an ionic substance is dissolved in a polar substance.

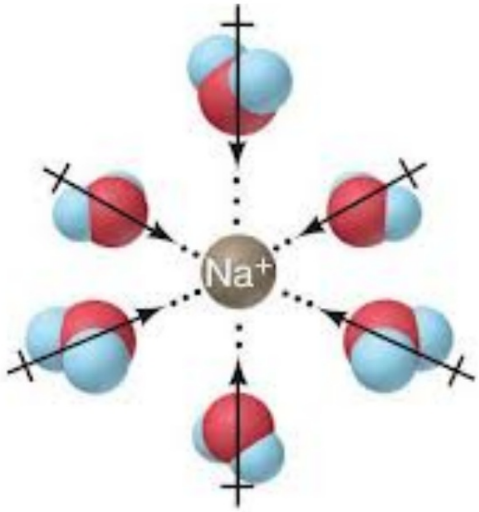


Examples:

1. NaCl in H_2O

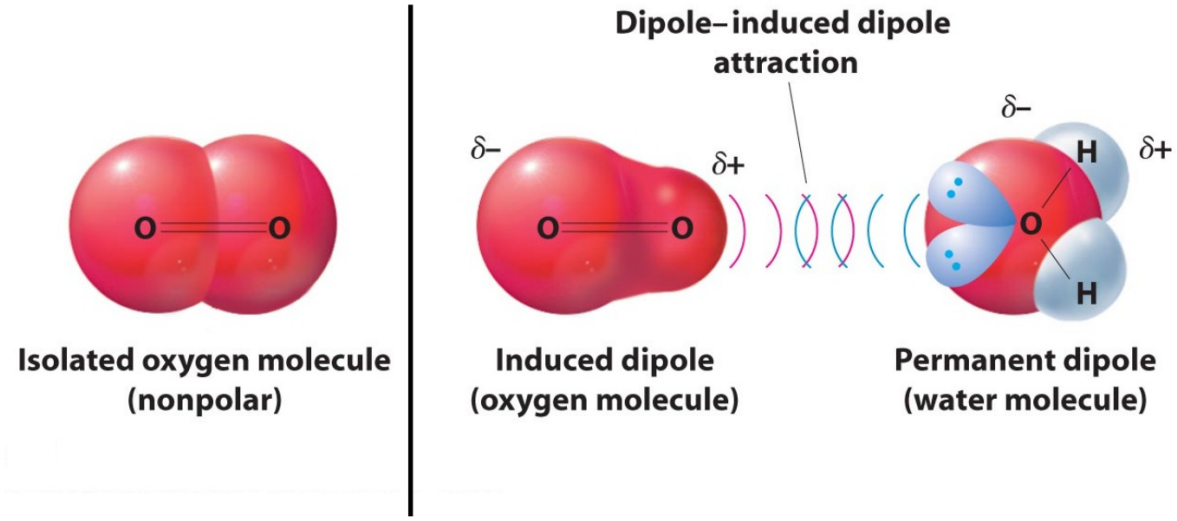
2. $MgCl_2$ in NH_3

3. KBr in $TeBr_4$



Induced Dipole Interactions

Two varieties: (1) dipole - induced dipole
(2) ion - induced dipole

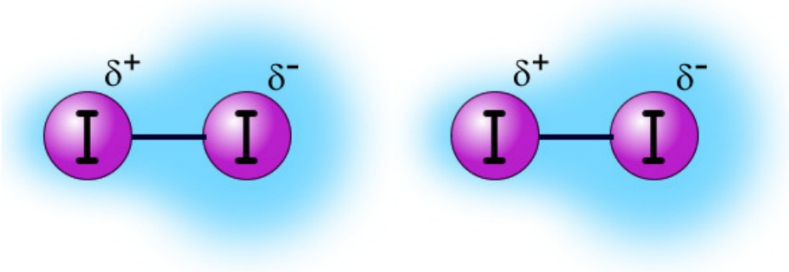


What would an ion-induced dipole interaction look like?

London Dispersion Forces
(van der waals forces)

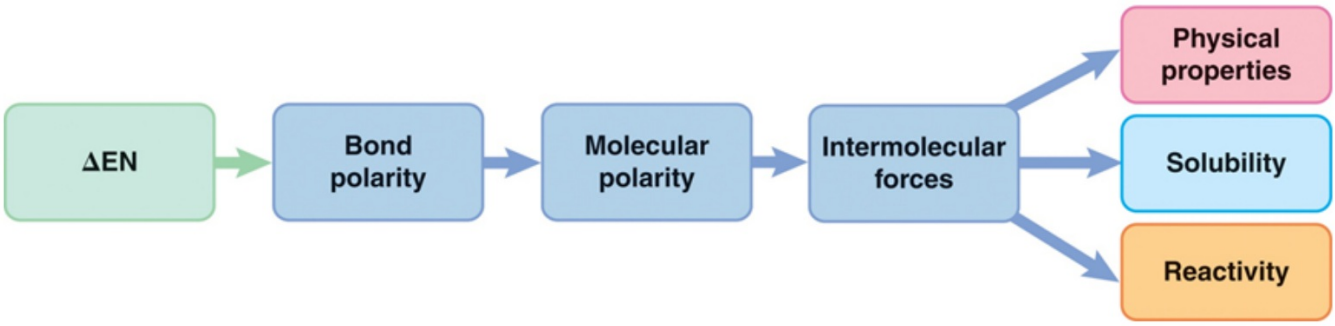
Weak attraction between the opposite ends of different molecules

Weakest of all IMFs



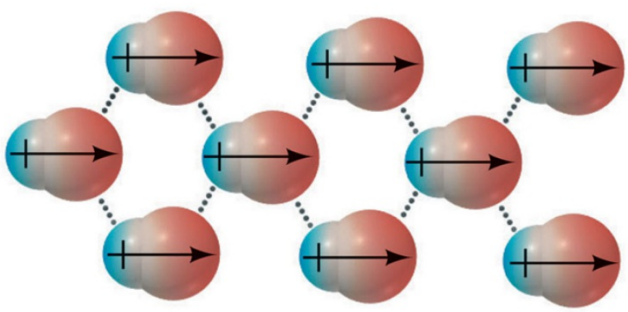
Occurs between all molecules

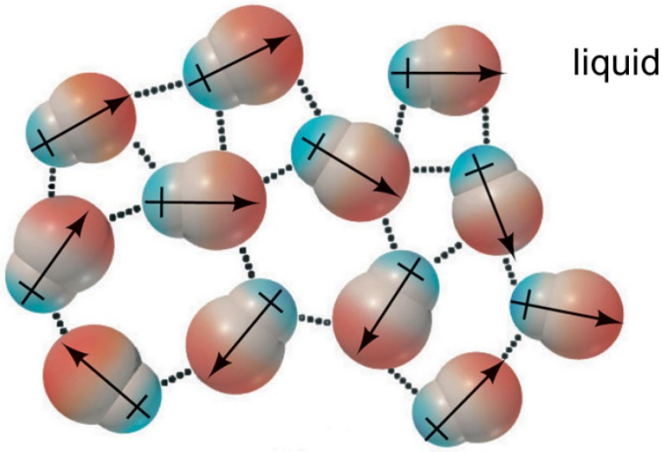
The Significance of IMFs



Map indicating the connection between electronegativity and the chemical and physical characteristics of substances.

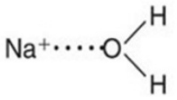
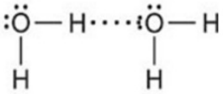
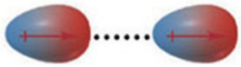
The Significance of IMFs



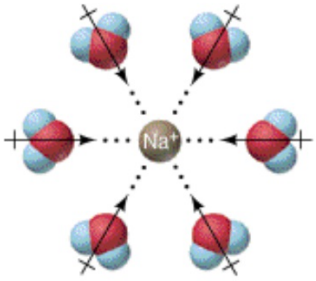


Intermolecular Forces dictate properties on the macroscopic level.

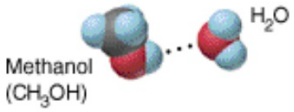
Table 12.2 Comparison of Bonding and Nonbonding (Intermolecular) Forces

Nonbonding (Intermolecular)				
Ion-dipole		Ion charge–dipole charge	40–600	
H bond		Polar bond to H–dipole charge (high EN of N, O, F)	10–40	
Dipole-dipole		Dipole charges	5–25	I—Cl····I—Cl
Ion–induced dipole		Ion charge–polarizable e^- cloud	3–15	Fe^{2+}····O_2
Dipole–induced dipole		Dipole charge–polarizable e^- cloud	2–10	H—Cl····Cl—Cl
Dispersion (London)		Polarizable e^- clouds	0.05–40	F—F····F—F

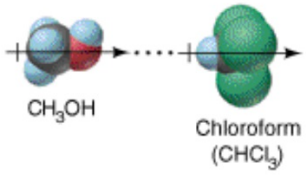
Summary of Intermolecular Forces



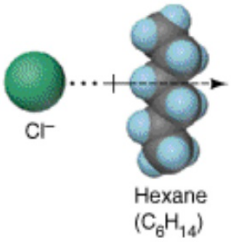
Ion-dipole



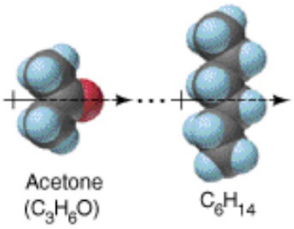
H bond



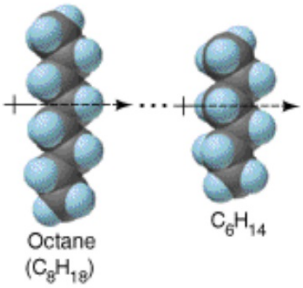
Dipole-dipole



Ion-induced dipole



Dipole-induced dipole



Dispersion