AL-Mustaqbal university
Pharmacy college

Physical pharmacy I

Lecture1

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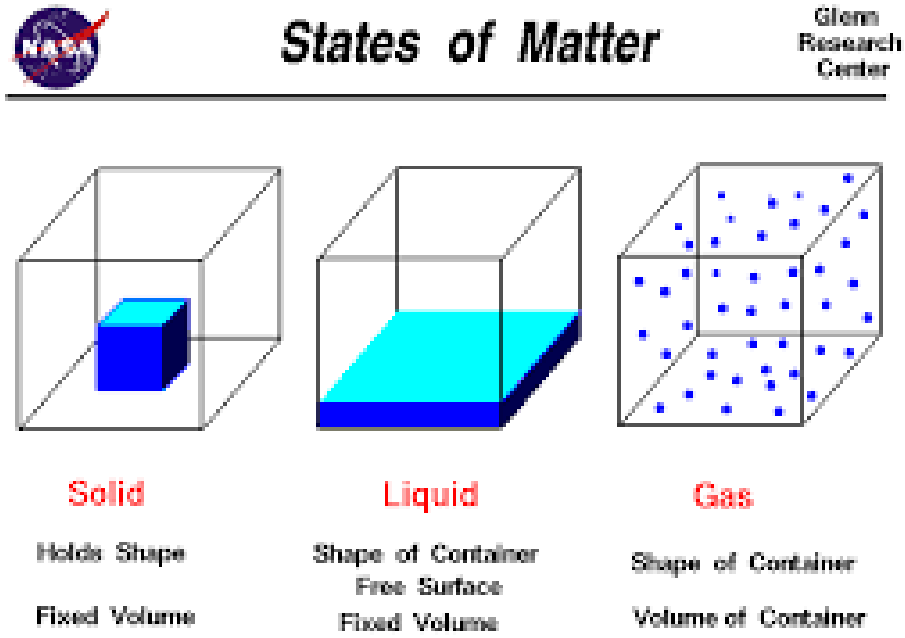
States of matter

Part 1

- Learn the differences between the solid, liquid, and gas state ,and how the polarity of molecules influences those states.
- Learn the different types of intermolecular forces between molecules.



States of matter

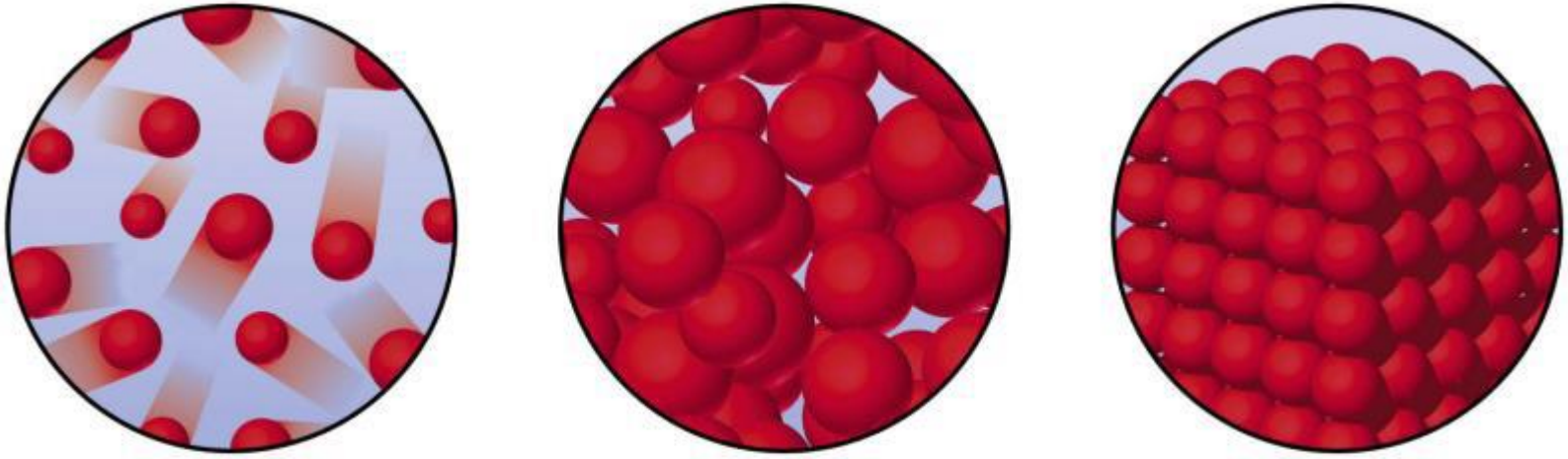
1. Gaseous state
2. Liquid state
3. Solid and crystalline state
4. Liquid crystalline state

Gases vs. Liquids and Solids

• In gases, the particles in the sample are widely separated, because the attractive forces between the particles are very weak.

• In liquids, there are strong intermolecular forces between the particles, which hold them in close contact, while still letting them slip and slide over one another.

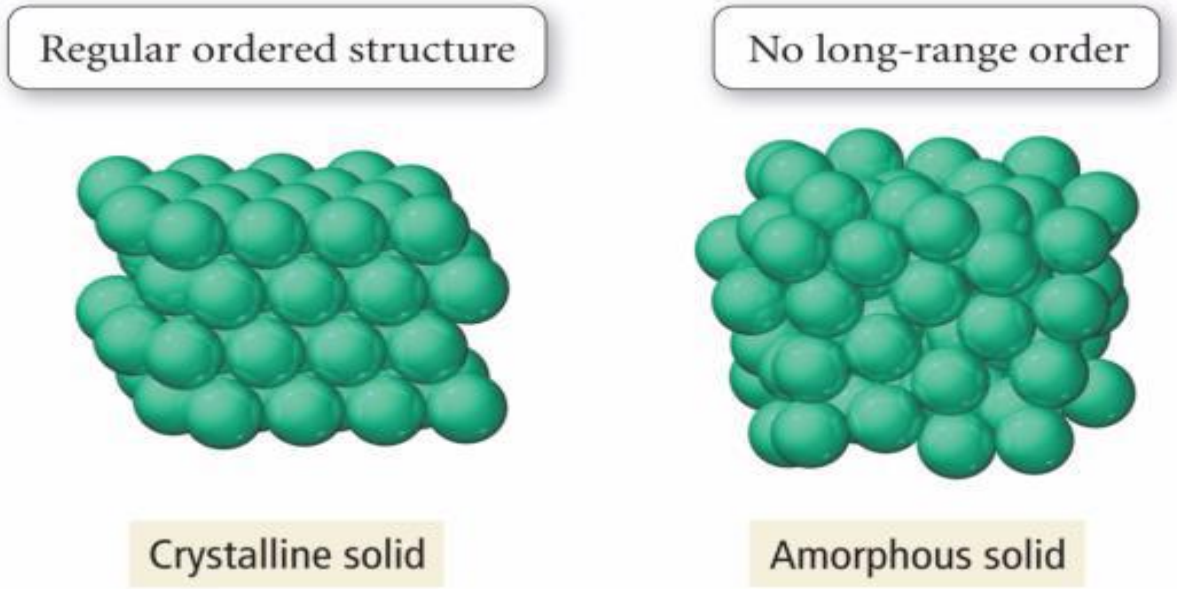
• In solids, the intermolecular forces are so strong that the particles are held rigidly in place



The Physical States of Matter

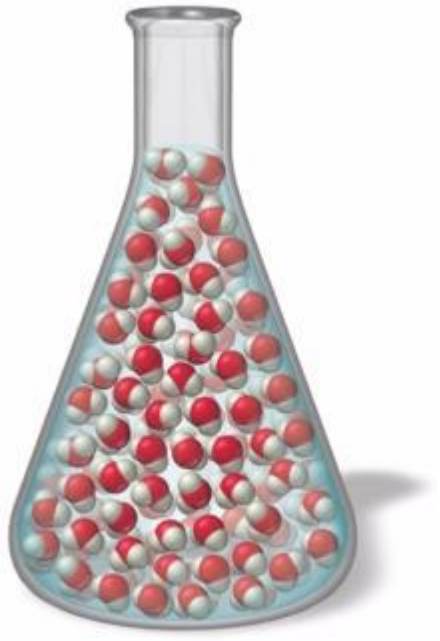
- **Solids**

✓ have strong intermolecular forces.
✓ have high **densities** in comparison to gases.
✓ are rigid (have a definite shape) and incompressible (have a definite volume).
✓ may be crystalline (ordered) [e.g. table salt] or amorphous (disordered) [e.g., plastics].



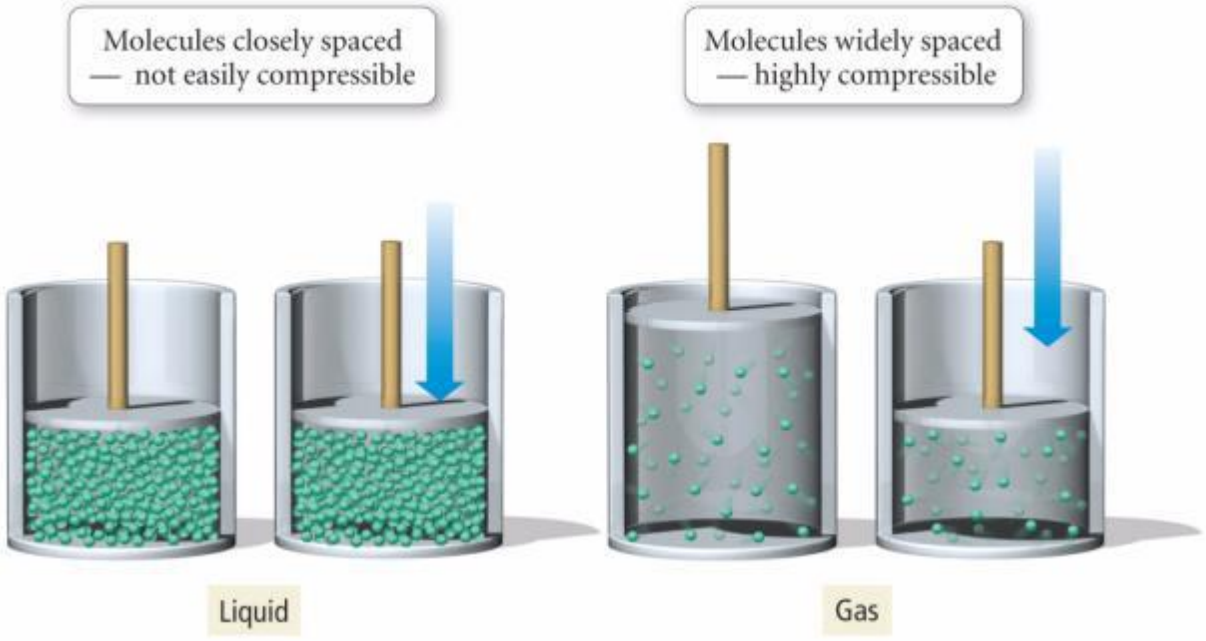
- **Liquids**

✓ have moderate intermolecular forces.
✓ have high densities in comparison to gases.
✓ are fluid (they flow, and have an indefinite shape) and incompressible (have a definite volume); they conform to the shape of their containers (they form surfaces).



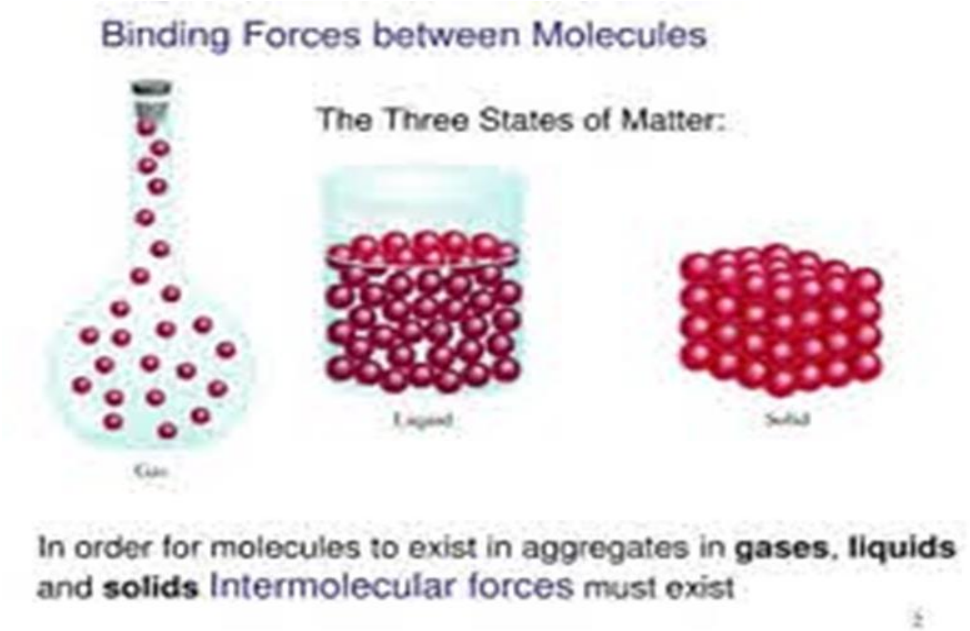
- **Gases**

✓ have weak intermolecular forces.
✓ have low densities
✓ are fluid and compressible; they have no definite shape or volume, and conform to the container shape, but fill the entire volume (i.e., they do not form surfaces).



Binding Forces Between Molecules

- Repulsive and attractive forces
- Intramolecular forces
- Intermolecular forces
- Bond energy

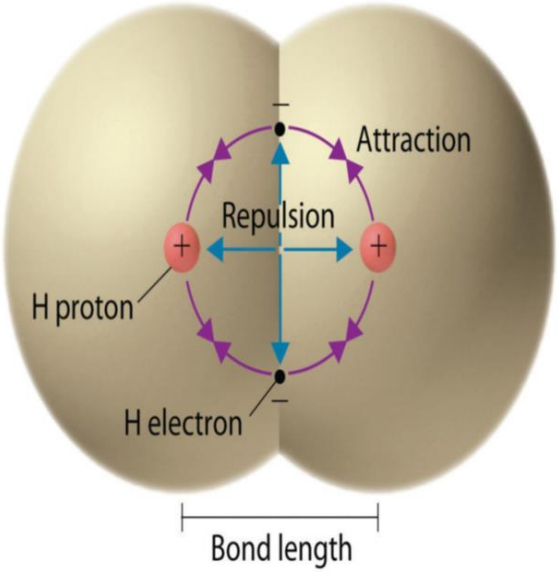


➢ Repulsive and Attractive Forces

For molecules to exist as aggregates in gases ,liquids ,and solids ,**intermolecular** forces must exist.
These intermolecular forces involve both attractive and repulsive forces. These forces must be balanced in an energetically favored arrangement for the molecules to interact.

H-CL--------H2O

intermolecular force



When molecules interact, both repulsive and attractive forces operate.

- As two atoms or molecules are brought closer together, the opposite charges and binding forces in the two molecules are closer together than the similar charges and forces, causing the molecules to attract one another.
- The negatively charged electron clouds of molecules largely govern the balance (equilibrium) forces between the two molecules .When the molecules are brought so close that the outer charge clouds touch, they repel each other like rigid elastic bodies.

Thus, attractive forces are necessary for molecules to cohere, whereas repulsive forces act to prevent the molecules from interpenetrating and crushing each other.

• Just as the actions of humans are often influenced by a conflict of loyalties, so too is molecular behavior governed by attractive and repulsive forces.

Repulsion is due to the interpenetration of the electronic clouds of molecules and increases exponentially with a decrease in distance between the molecules. At a certain equilibrium distance, about (3-4)x 10−8 cm (3–4 Å), the repulsive and attractive forces are equal. At this position, the potential energy of the two molecules is a minimum and the system is most stable in the following figure

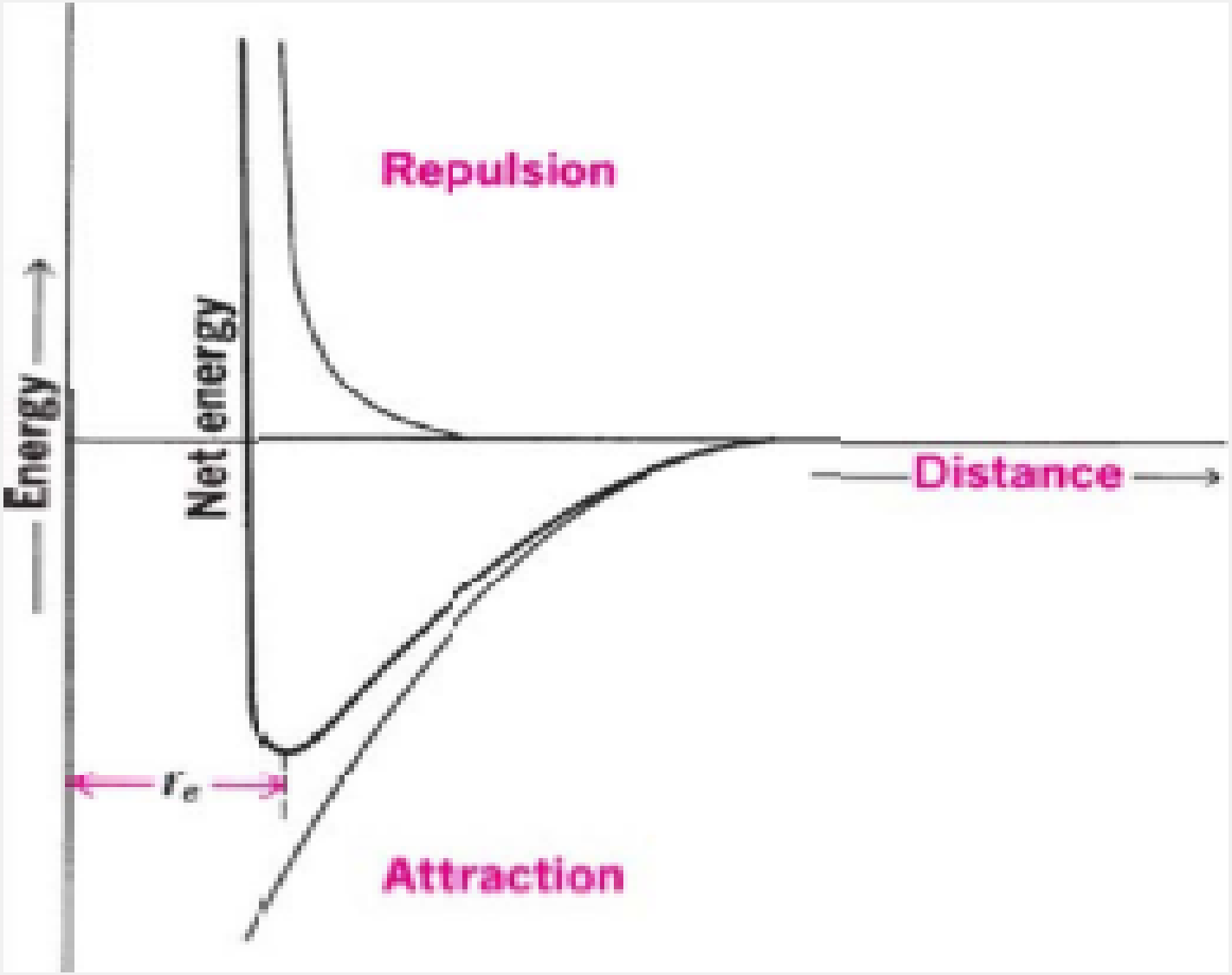


Fig. 2-1. Repulsive and attractive energies and net energy as a function of the distance between molecules. Note that a minimum occurs in the net energy because of the different character of the attraction and repulsion curves.

➢ Intramolecular forces and Intermolecular forces

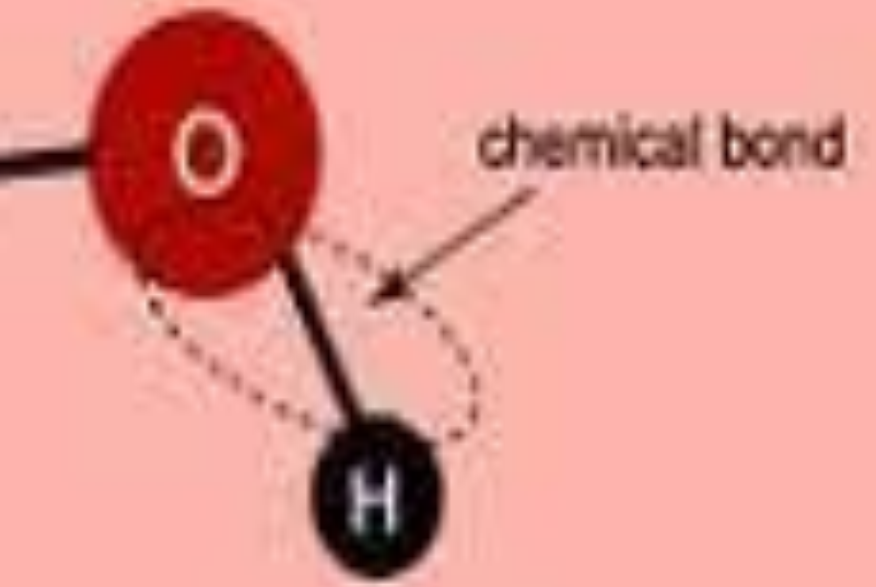
For molecules to exist as aggregates in gases, liquids, and solids, **inter**molecular forces must exist.

- **Cohesion:** the attraction of like molecules
- **adhesion**: the attraction of unlike molecules are manifestations of intermolecular forces
- Repulsion is a reaction between two molecules that forces them apart

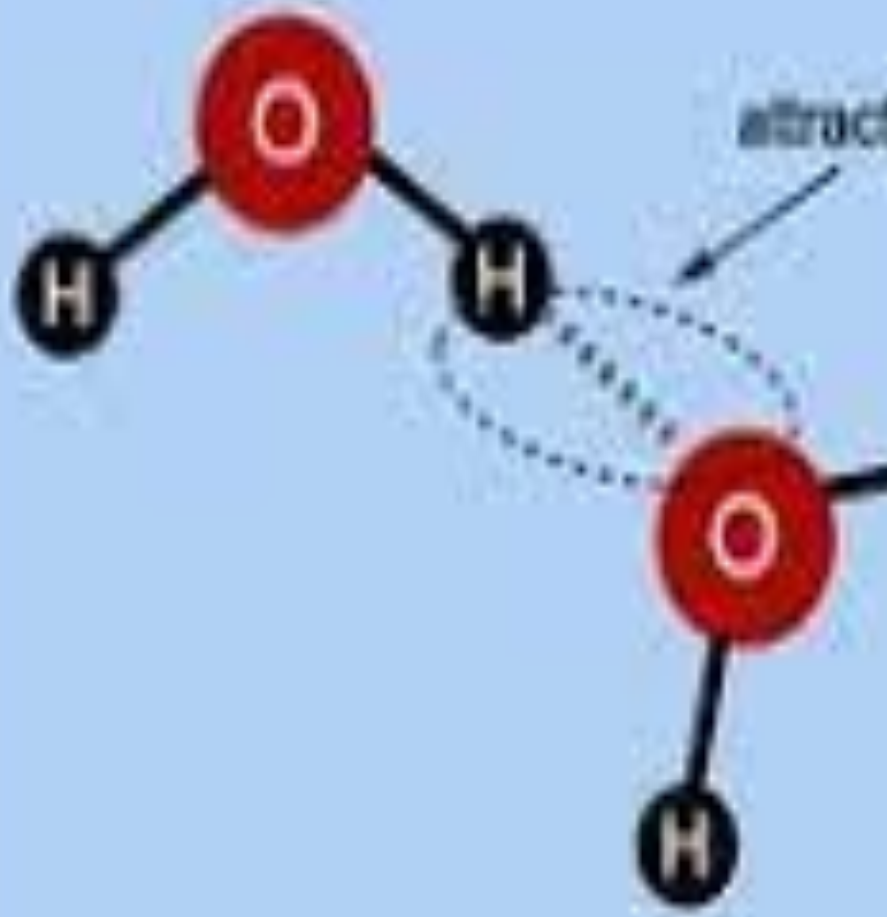
Intermolecular forces are forces between molecules

- Inter' means between, so these are the forces between molecules.
- **Intra**molecular forces act within molecules, which are the strong forces that keep a molecule together.
- Intra' means inside, so these are the inside forces in a molecule.
- Intermolecular forces are weaker than intramolecular forces

RA: inside the molecule



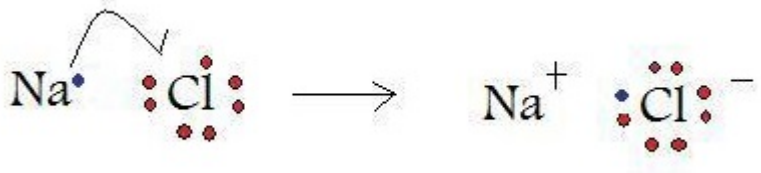
INTER: between 2 mole



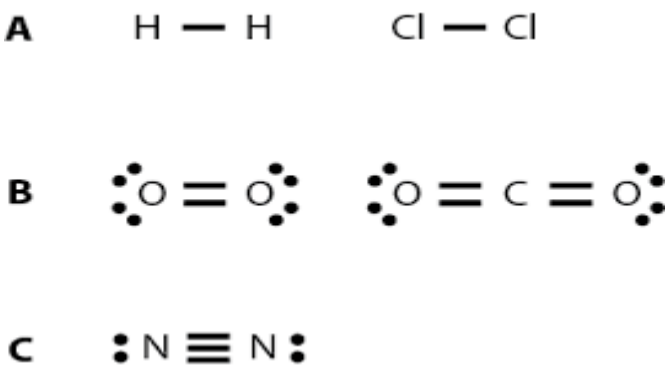
➢Intramolecular forces

Types of intramolecular forces of attraction

1-Ionic bond: This bond is formed by the complete transfer of valence electron(s) between atoms.

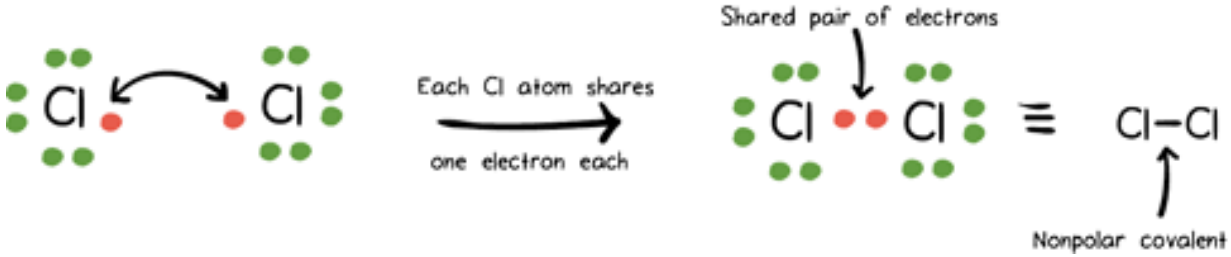


2-Covalent bond: This bond is formed between atoms that have similar electro negativities—the affinity or desire for electrons. they share electrons in order to achieve octet configuration and become more stable ; (three type single ,double &triple bond)

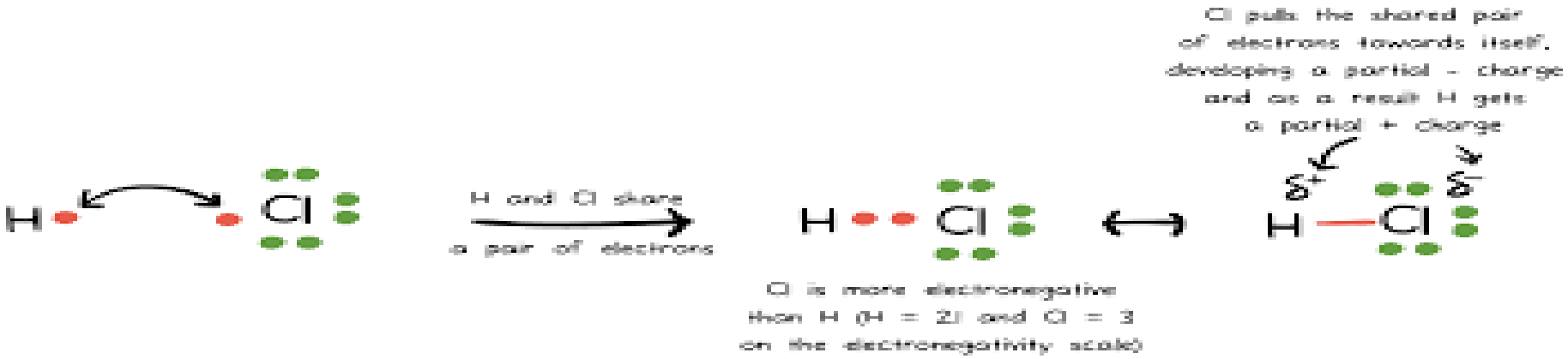


Covalent bond

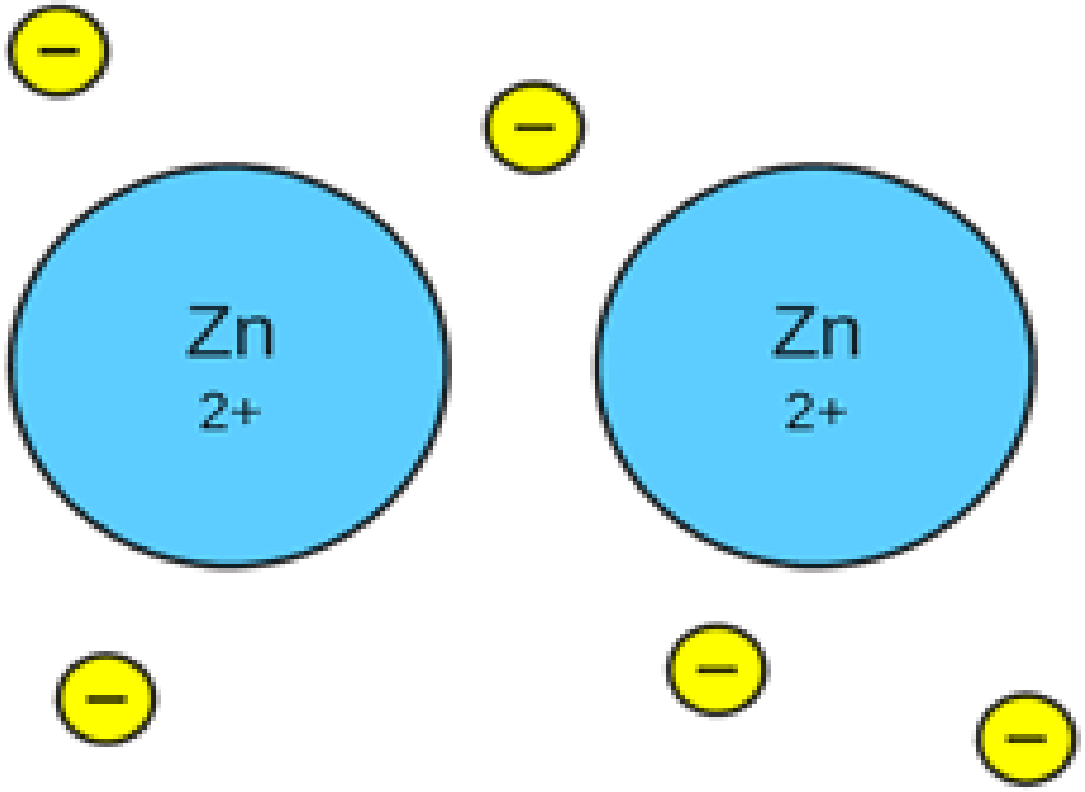
A nonpolar covalent bond is formed between **same** atoms or atoms with very similar electronegativities



A polar covalent bond is formed when atoms of slightly **different** electronegativities share electrons.



3-Metallic bonding: This type of covalent bonding specifically occurs between atoms of metals



➢ Intermolecular forces

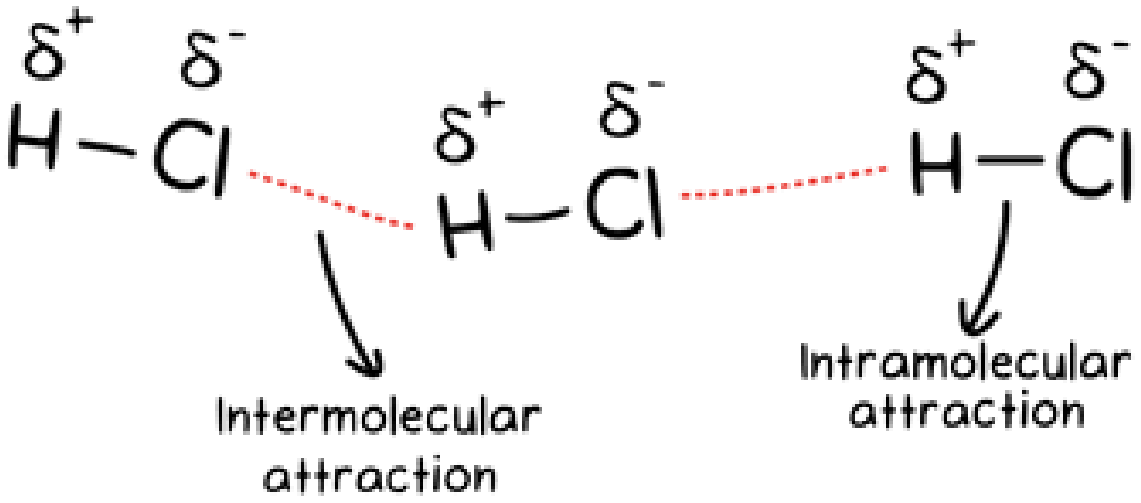
Intermolecular forces occur between molecules . It can be divided in to:

1.Vanderwaals forces

2.Ion–dipole interaction

3.Ion–induced dipole interaction

4.Hydrogen bonds



Intermolecular forces

1-VanderWaals Forces

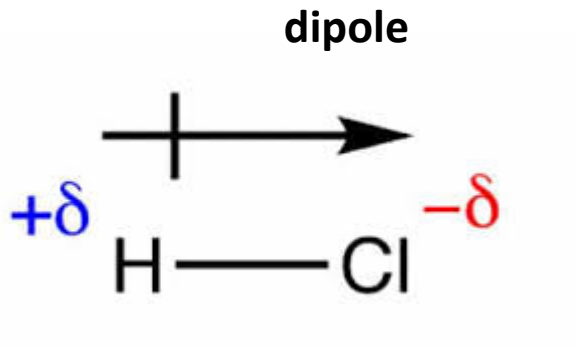
VanderWaal interactions are **weak forces** that involve the dispersion of charge across a molecule called adipole.

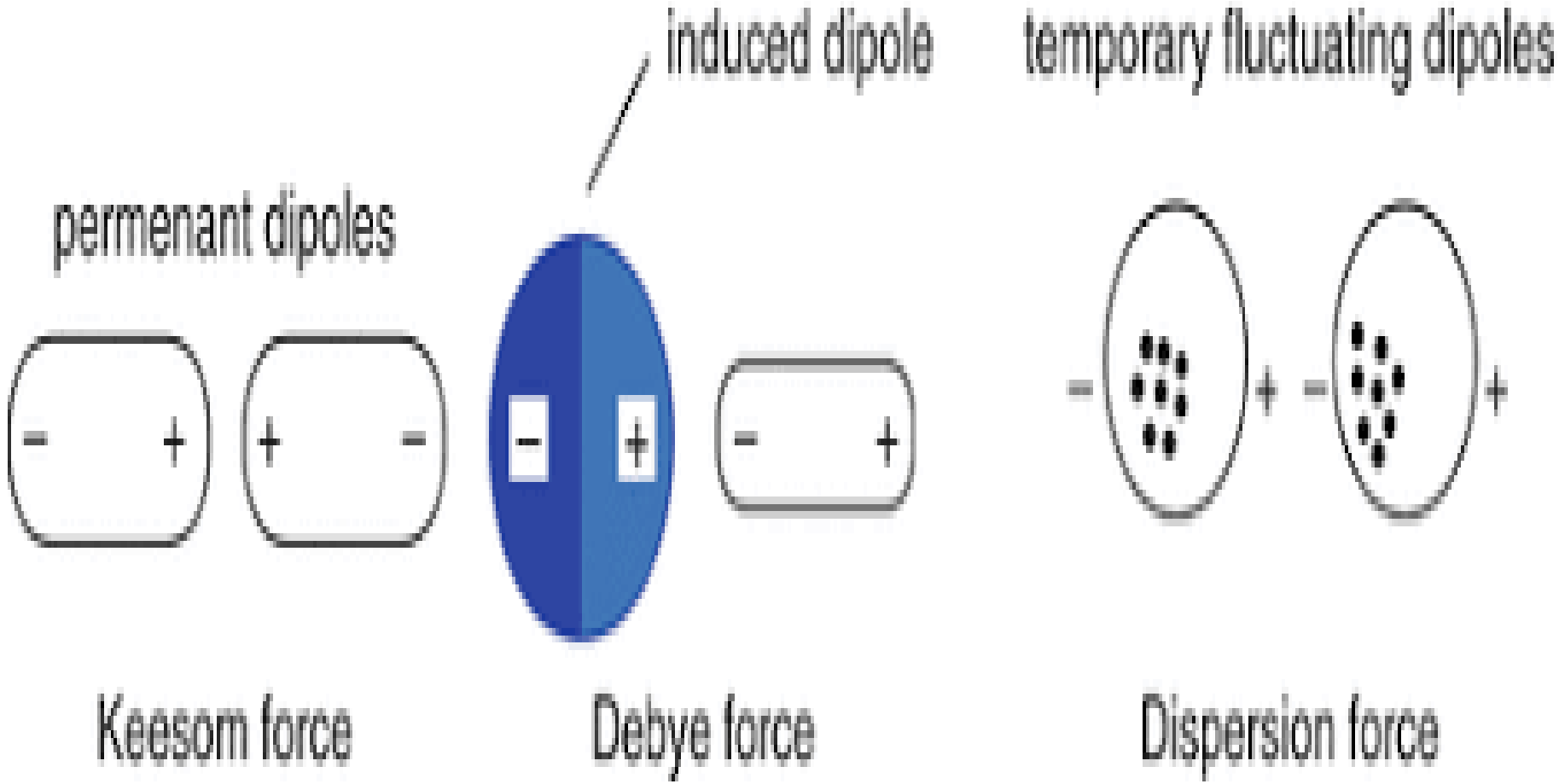
VanderWaal interactions can be classified into:

A. Dipole–dipole interaction ,orientation effect ,or **Keesom force**

B. Dipole-induced dipole interaction ,induction effect ,or **Debye force**

C. Induced dipole induced dipole interaction ,dispersion effect ,or **London force**



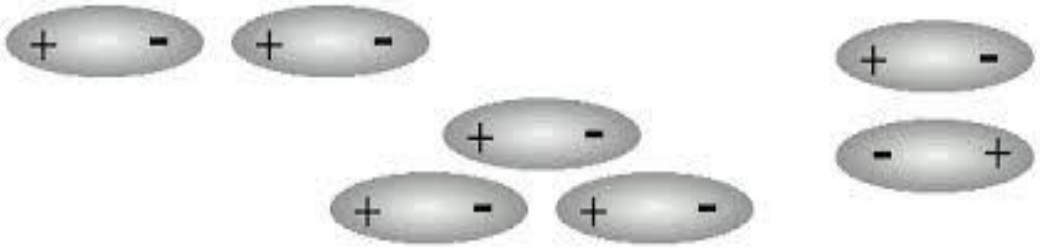

induced dipole
temporary fluctuating dipoles
permenant dipoles
Keesom force
Debye force
Dispersion force

Keesom forces

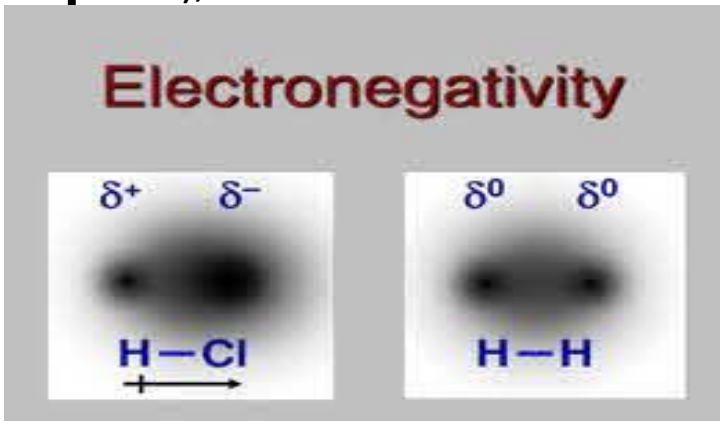
Keesom forces occur between polar molecules in which the permanent dipoles interact with one an other(**dipole-dipole interactions)or(orientation effect**)

Polar molecules have polar covalent bonds which are unevenly distributed in space due to the difference in the electronegativity of the atoms forming the bond .e.g. HCl.

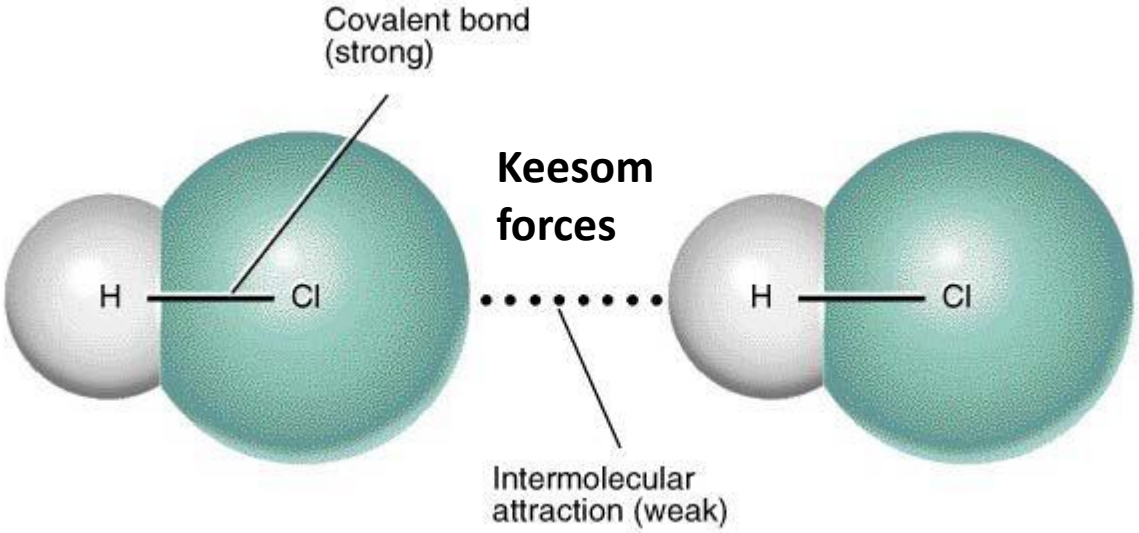
The nucleus of the chlorine atom pulls the electron pair involved in the chlorine hydrogen bond closer to itself and creates a permanent partial positive charge on the hydrogen and a permanent partial negative charge on the chlorine(**Permanent dipole**),



Attractive Dipole-Dipole Interactions



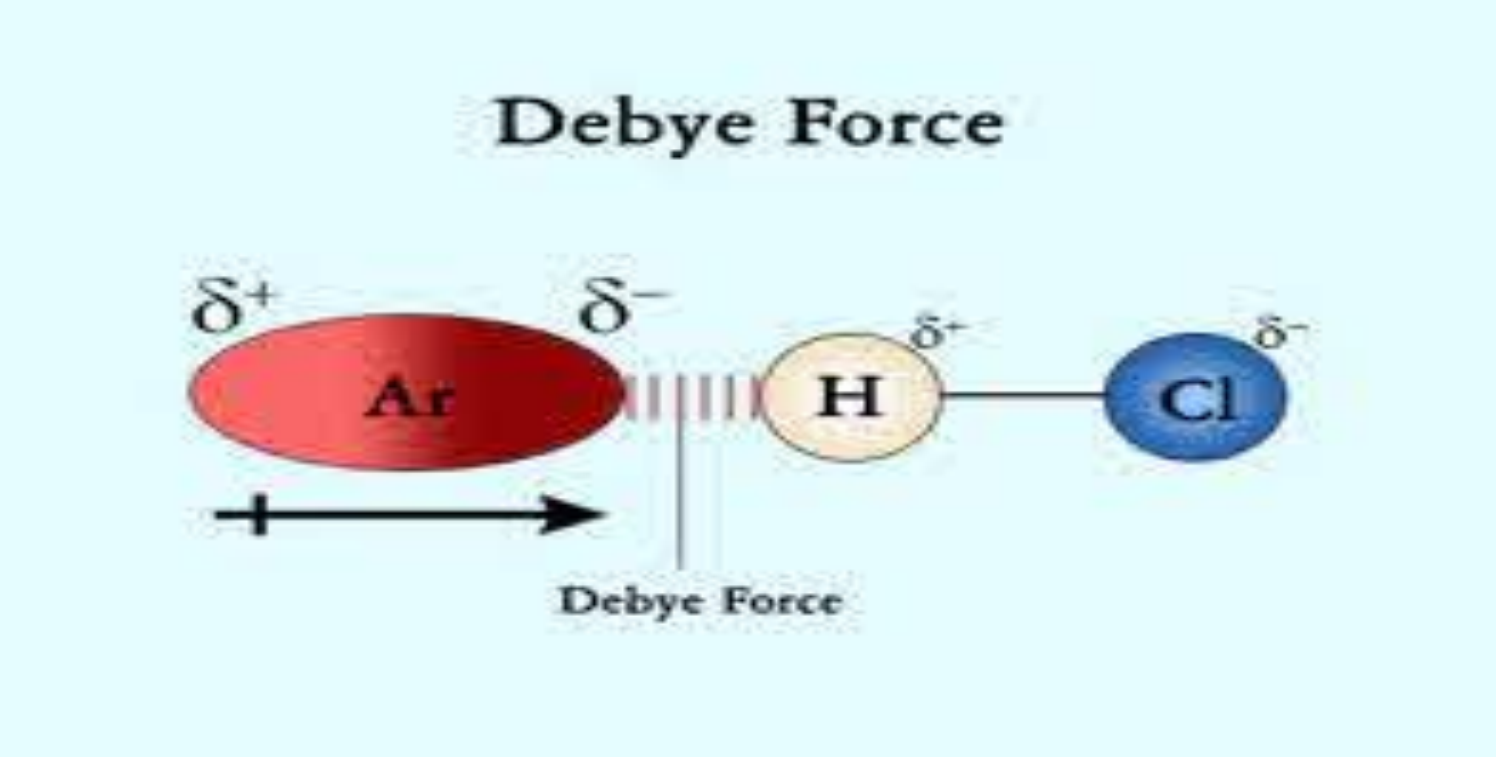
The Partial **opposite** charges (permanent dipoles) attract one another(**dipole-dipole interactions**)

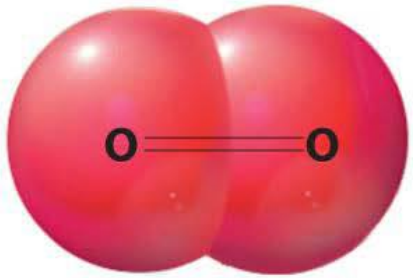


The dipole-dipole forces increases as the polarity of the molecule increases .Keesom forces are **much weaker** than ionic bonds because the charges involved in bonding are partial

Debye forces

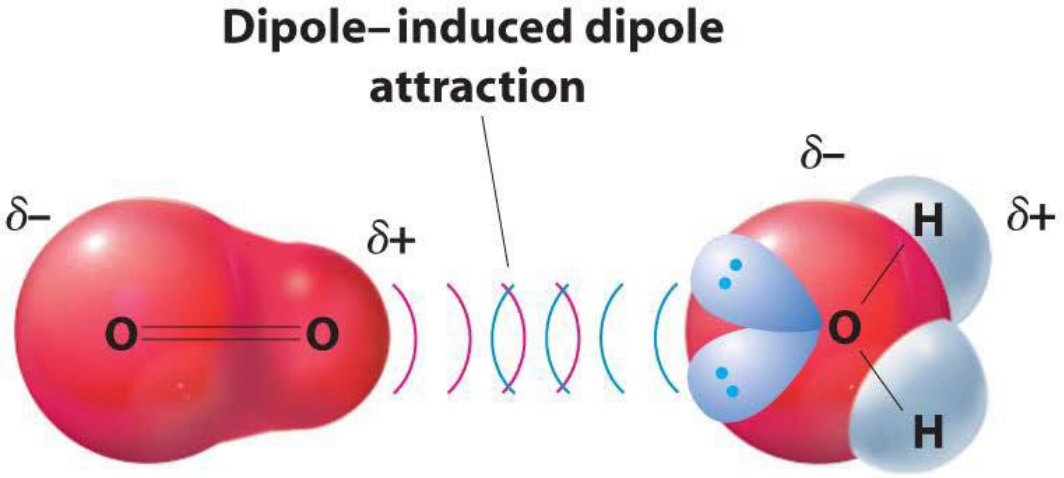
Debye forces occur between a polar and a non polar molecule in which the permanent dipole in the polar molecule Induce an electric dipole in the non polar one(**dipole-induced dipole interactions**)or(**induction effect**).e.g. water and oxygen





Isolated oxygen molecule
(nonpolar)

(a)

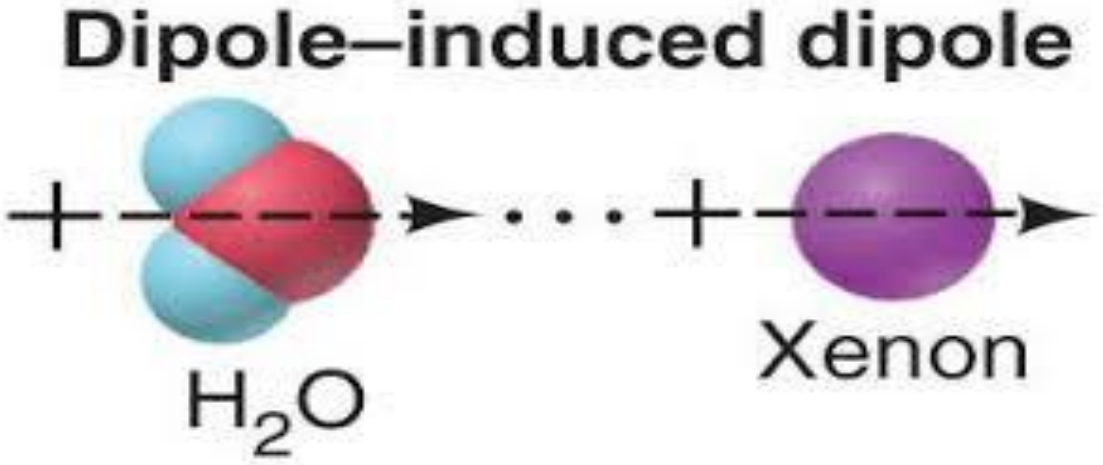


Induced dipole
(oxygen molecule)

Permanent dipole
(water molecule)

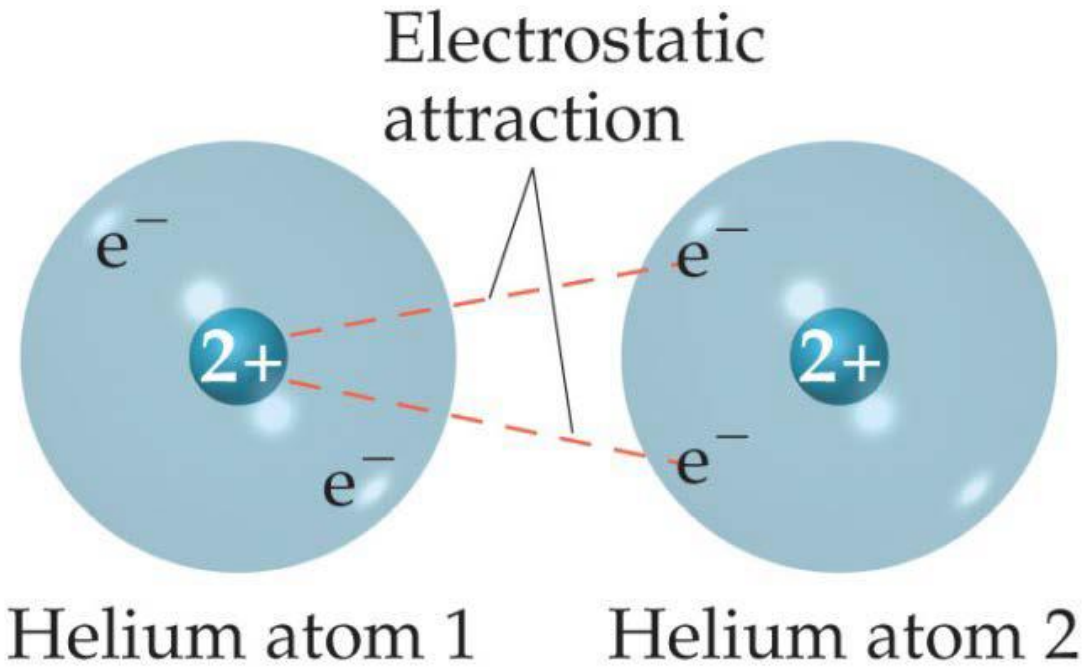
(b)

The strength of **Debye forces** increases with the ease of distortion of the electron cloud of the nonpolar molecule(i.e. polarizability of the molecule)
Debye forces is **weaker than Keesom forces** because the dipole in the nonpolar molecule is temporary(induced)and forms only when the two molecules is extremely close to each other

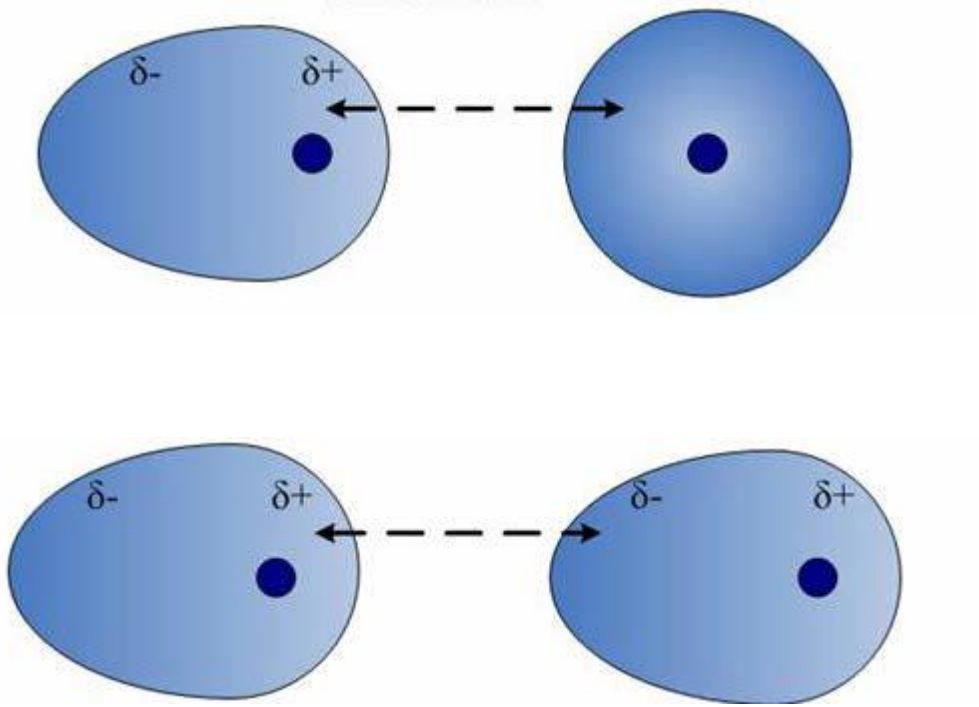


London forces

London forces occur between two nonpolar(neutral)molecules in which molecules can induce polarity on each other(**induced dipole-induced dipole interactions**)or(**dispersion effect**).e.g. Helium



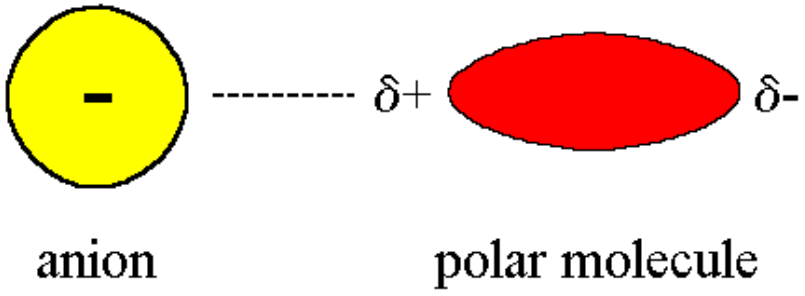
Two Helium atoms are nonpolar and posses no dipoles .The average distribution of electrons around each nucleus is spherically symmetrical

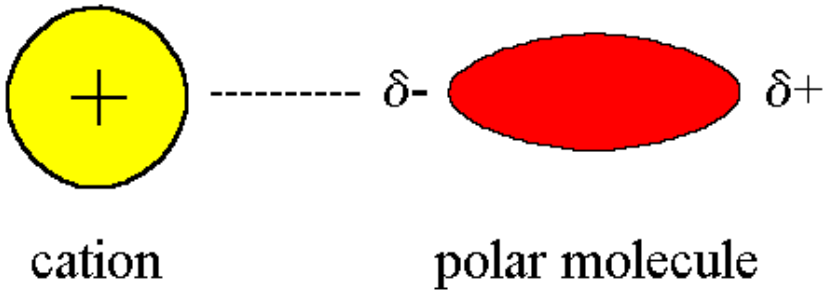


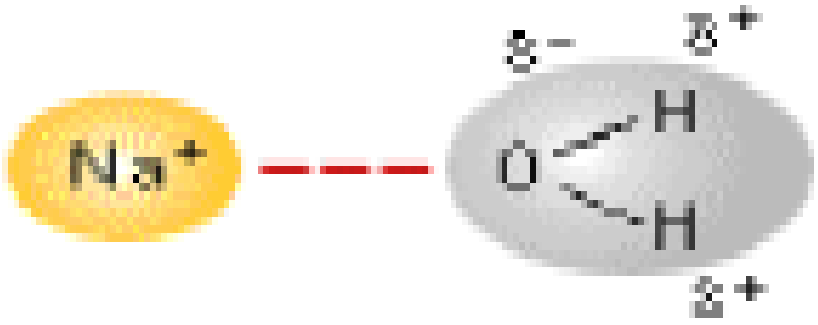
2- Ion-dipole interaction

They occur between polar or non-polar molecules and ion.

•These types of interactions account in part for the **solubility of ionic** crystalline substances in water, the cation for example attracting the relatively negative oxygen atom of water and the anion attracting the hydrogen atoms of the dipolar water molecules. .



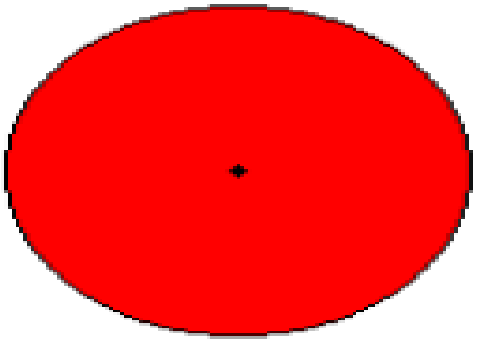




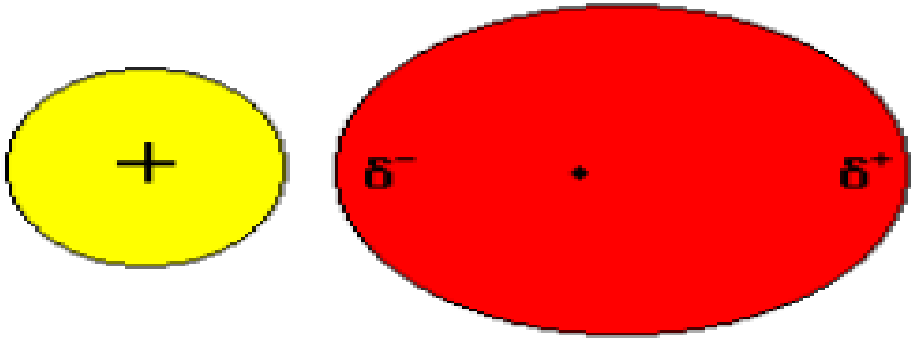
3-Ion-induced dipole interaction

Ion Induced dipole forces occur between a **charged ion** and a **nonpolar** molecule.
These forces result when the approach of an ion induces a dipole in an atom or in a nonpolar molecule by disturbing the arrangement of electrons Ion-induced dipole forces are presumably involved in the formation of the iodide complex and accounts for solubility of iodide in a solution of potassium iodide.

$$I_2+K+I^-=K+I_3^-$$



Spherical atom with no dipole.
The dot indicates the location of the nucleus.

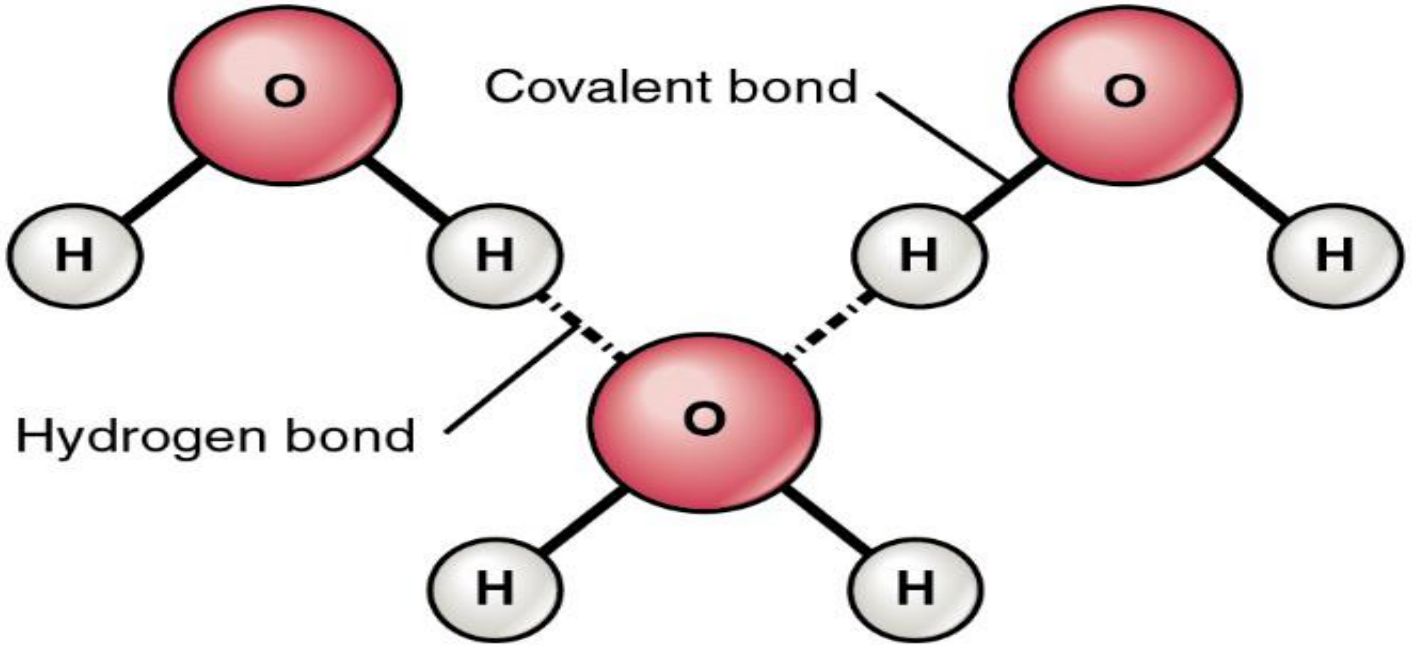


Upon approach of a charged ion, electrons in the atom respond and the atom develops a dipole.

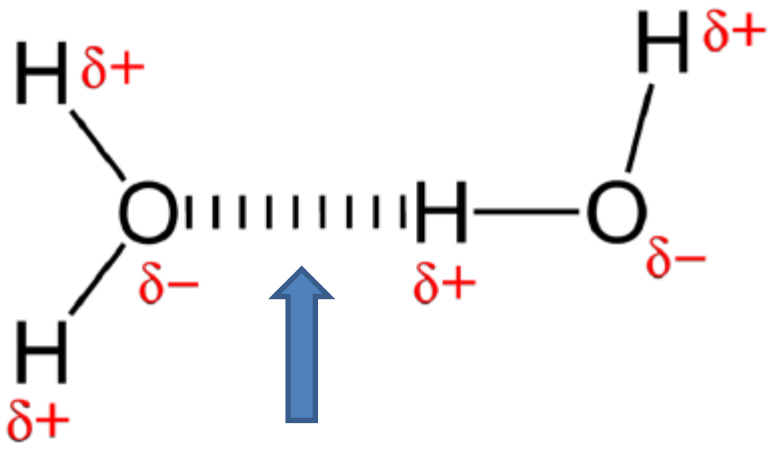
4-Hydrogen bond

Hydrogen bond is a strong type of dipole-dipole interaction that occurs between a molecule containing a hydrogen atom and a strongly electronegative atom such as fluorine ,oxygen ,or nitrogen

In order to create the bond ,the hydrogen atom must be covalently attached to another electronegative atom



In a **water molecule** ,the hydrogen has single electron is pulled by the covalently attached oxygen atom ,creating a naked nucleus on the side of the hydrogen atom facing away(partial positive charge).

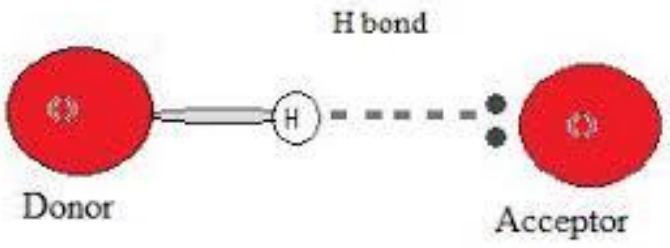


Hydrogen bond

Hydrogen bonds are responsible for many unusual physical properties of water including

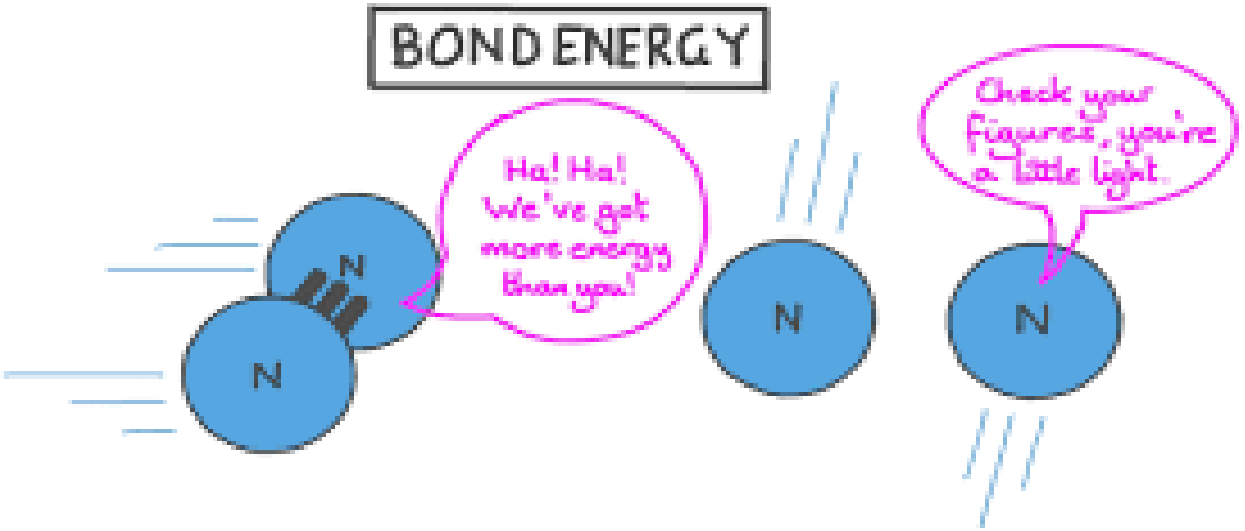
- ✓ **it's abnormally low vapor pressure ,**
- ✓ **high boiling point ,and the**
- ✓ **greater volume of ice water**.

Hydrogen bonding is stronger than all VanderWaals intermolecular forces (they are given their own classification) ,but are still weaker than ionic and covalent bonds



➢ Bond energy

Bond energy is a measure of bond strength.
It is the heat required to break one mole of molecules in to their individual atoms.




Thank you