CHAPTER NO

10

6 MK

STATES OF MATTER

(SOLIDS ,LIQUIDS, GASES)

LECTURE NO - 3

TYPES OF BONDS (TYPES OF FORCES)

PHYSICAL FORCE

INTERMOLECULAR FORCE

STRONG FORCE

Hydrogen Bonding

WEAK FORCE

1. Dipole – Dipole Interaction
2. Dipole – Induced dipole Interaction
3. Ion – dipole Interaction
4. Ion – Induced dipole Interaction
5. Instantaneous dipole – Induced dipole Interaction

CHEMICAL FORCE

INTRAMOLECULAR FORCE

1. Ionic Bond
2. Covalent Bond
3. Co-ordinate covalent Bond
4. Metallic bond

PHYSICAL FORCE/INTERMOLECULAR FORCE

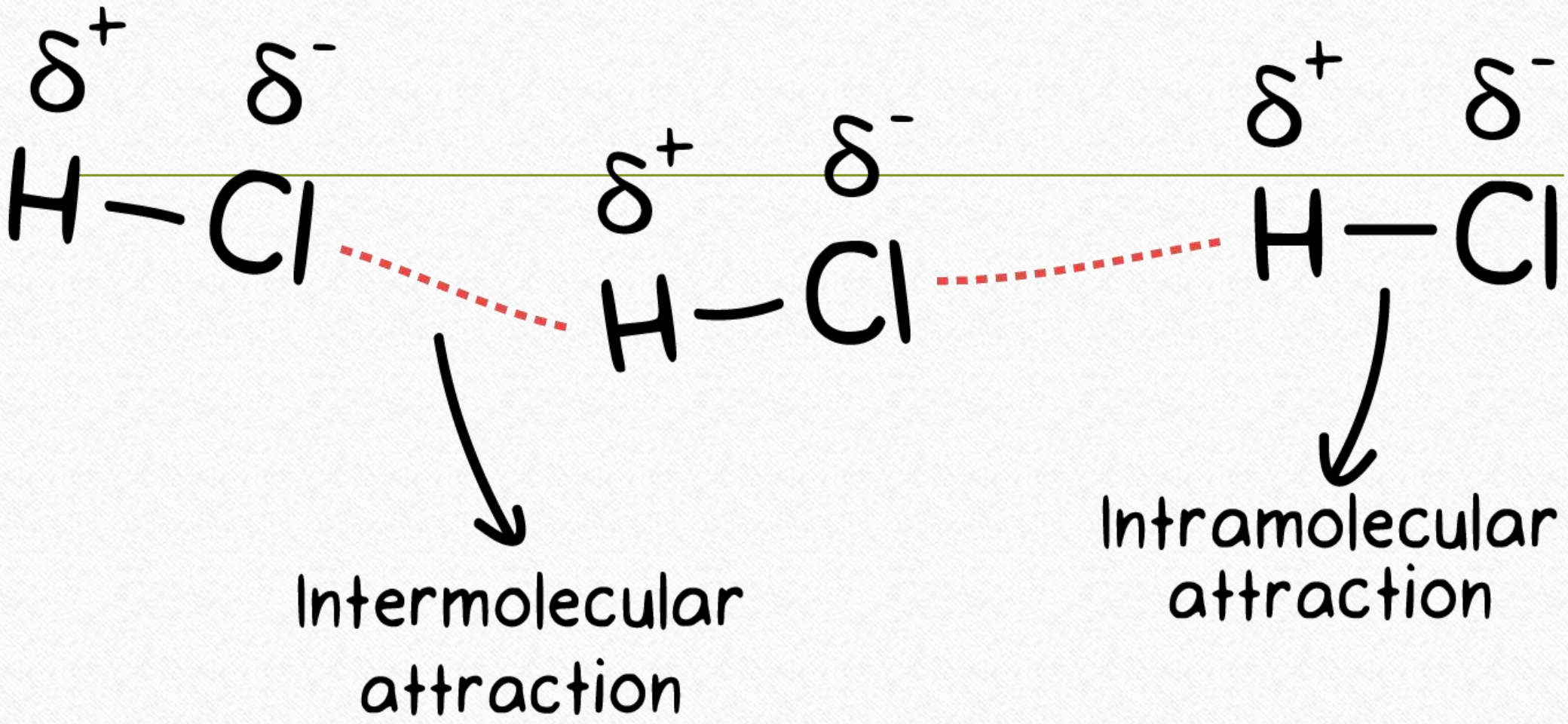
- A force of attraction between neighbouring molecule situated at distance much closer in comparison with their molecular diameter is called Intermolecular force.

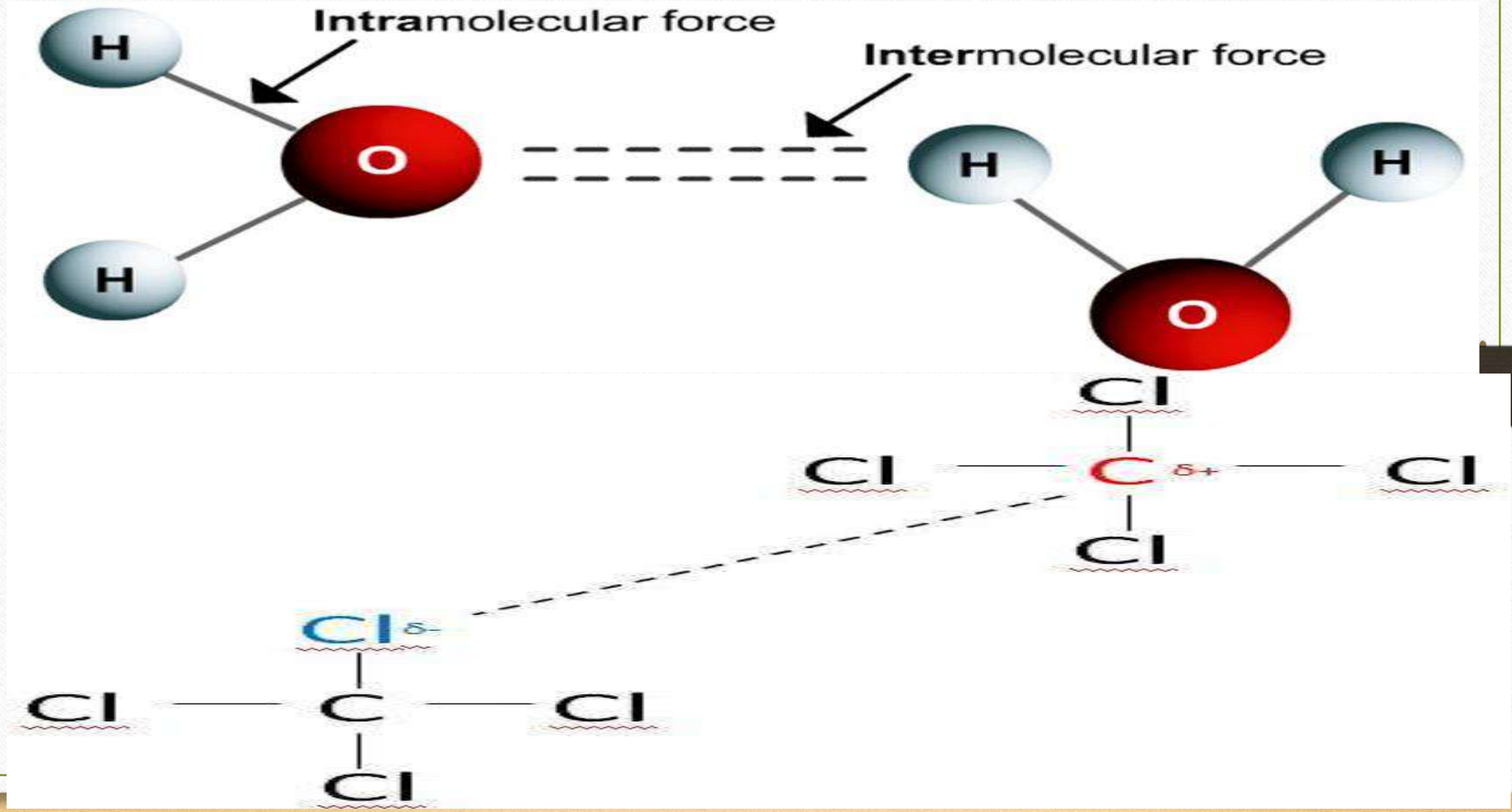
OR

DEFINITION

- **Intermolecular force** (IMF) is the force which mediate interaction between molecules, including force of attraction or repulsion which act between molecules and other types of neighboring particles, e.g. atoms or ions.

Examples:


δ+ δ-
H—Cl
δ+ δ-
H—Cl
δ+ δ-
H—Cl
Intermolecular attraction
Intramolecular attraction

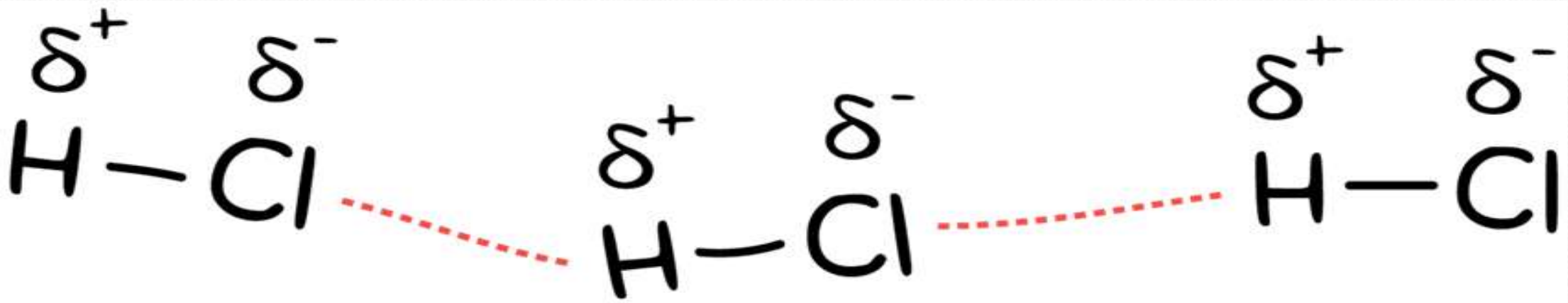

Intramolecular force
Intermolecular force
H
O
H
H
H
O
Cl
Cl
C
δ+
Cl
Cl
Cl
Cl
δ-
Cl
C
Cl
Cl

WEAK FORCE

1. Dipole – Dipole Interaction:

- It is observed between Polar molecules.
- It is a permanent Interaction.
- It is defined as the force of attraction exerts between neighbouring molecules having permanent dipole moment (non – zero value).
- The origin of dipole – dipole interaction is the electrostatic force of attraction.

- Examples: HCl, HBr, HI, H_2S, H_2O etc.

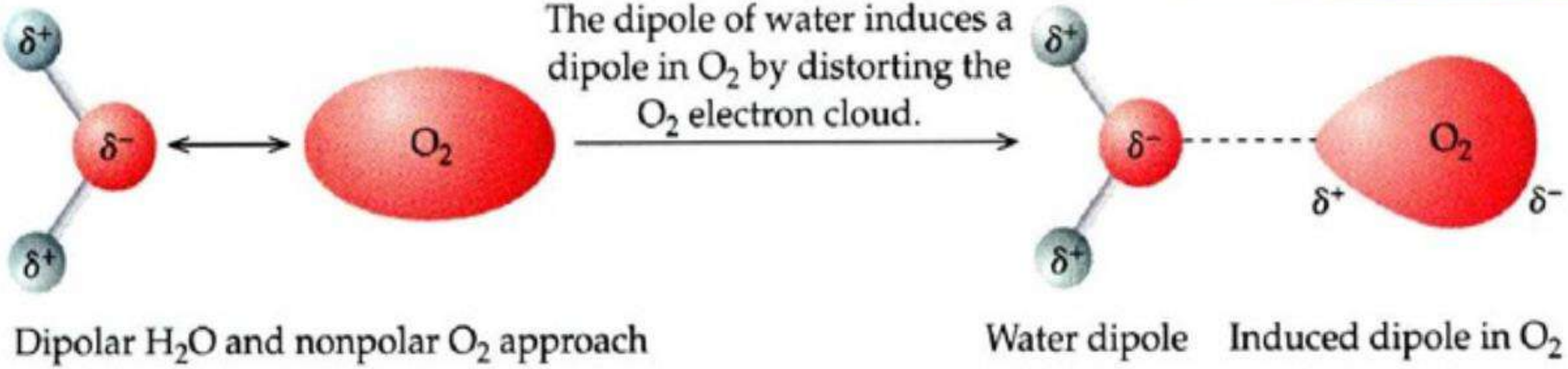


- Strength of Dipole – Dipole Interaction depends on dipole moment value of polar molecule.

  Higher the Dipole moment **Stronger** will be the dipole – dipole interaction.

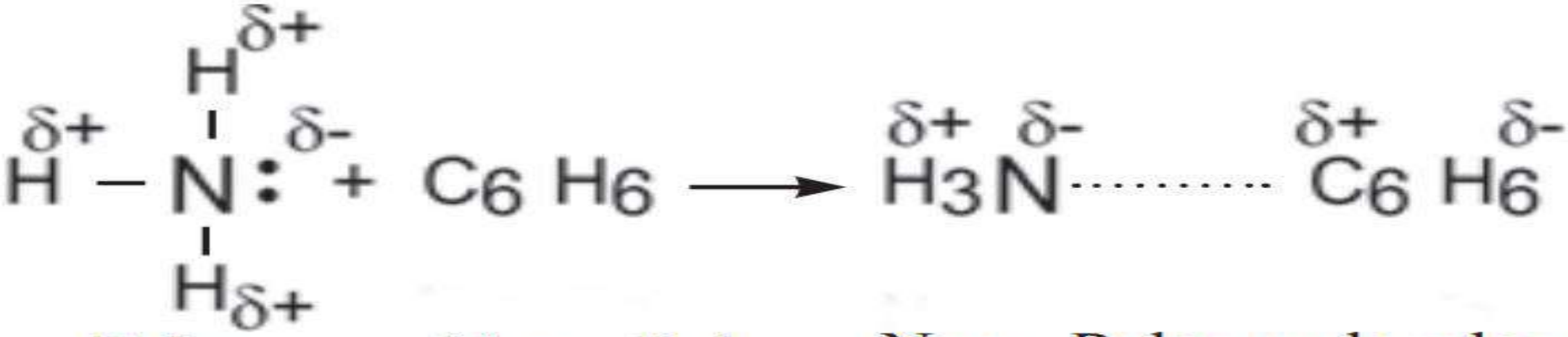
2. Dipole – Induced dipole Interaction:

- It is observed between Polar & Non polar molecule.
- It is a Temporary Interaction.
- It is defined as the force of attraction exerts between polar molecule having permanent dipole moment (non – zero value) and Non – polar molecule having zero dipole moment.
- Examples: Water with Oxygen molecule , Ammonia with Benzene, Iodine monochloride with Xenon atom etc.



Dipolar H_2O and nonpolar O_2 approach

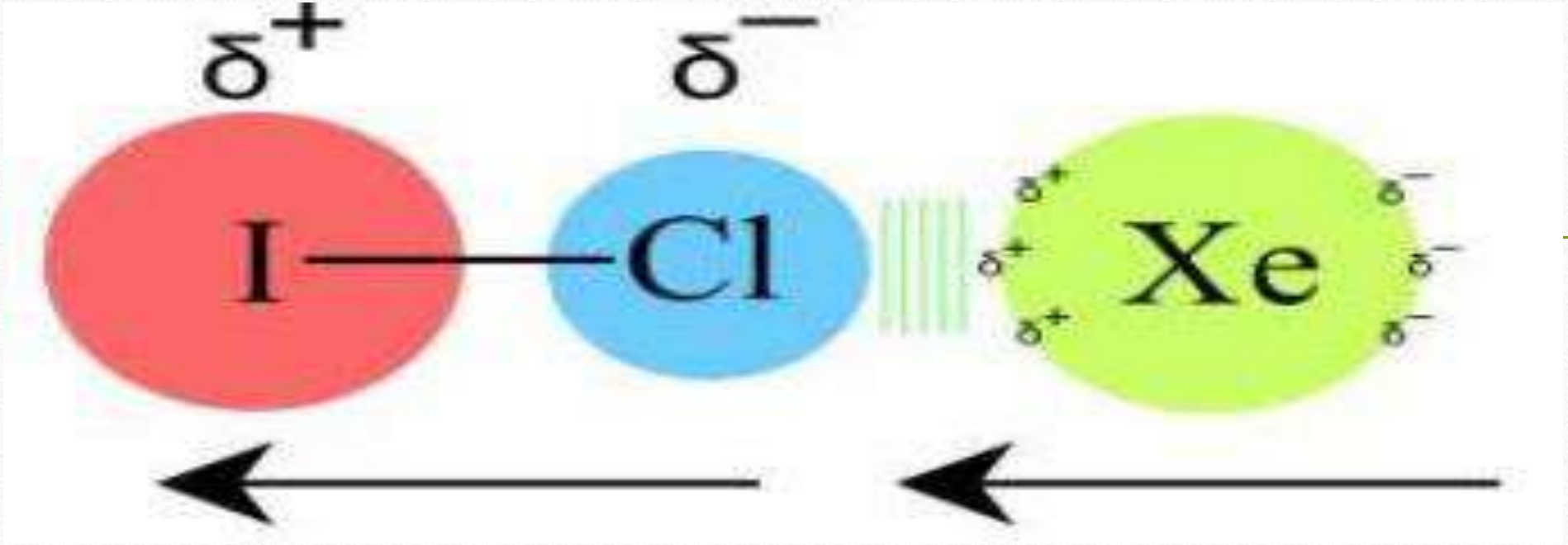
Water dipole Induced dipole in O_2



Polar molecular

Non - Polar molecular

Non - Polar molecular with induced dipole

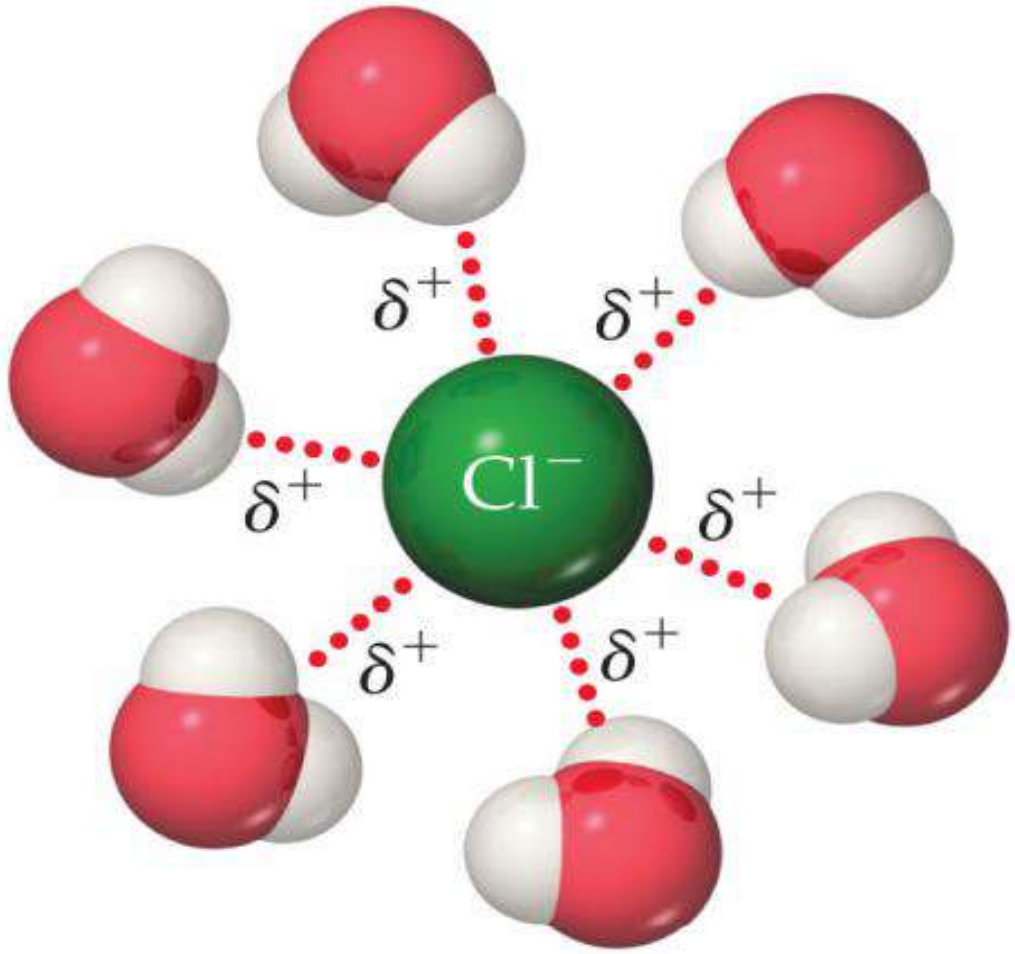

δ+
δ−
I
Cl
Xe
δ+
δ+
δ+
δ−
δ−
δ−

3. Ion – dipole Interaction:

- It is observed between Ion (Cation or Anion) & Polar molecule.
- It is a Permanent Interaction.
- It is defined as the force of attraction exerts between Ion (Cation or Anion) and Polar molecule having permanent dipole moment.
- Examples:

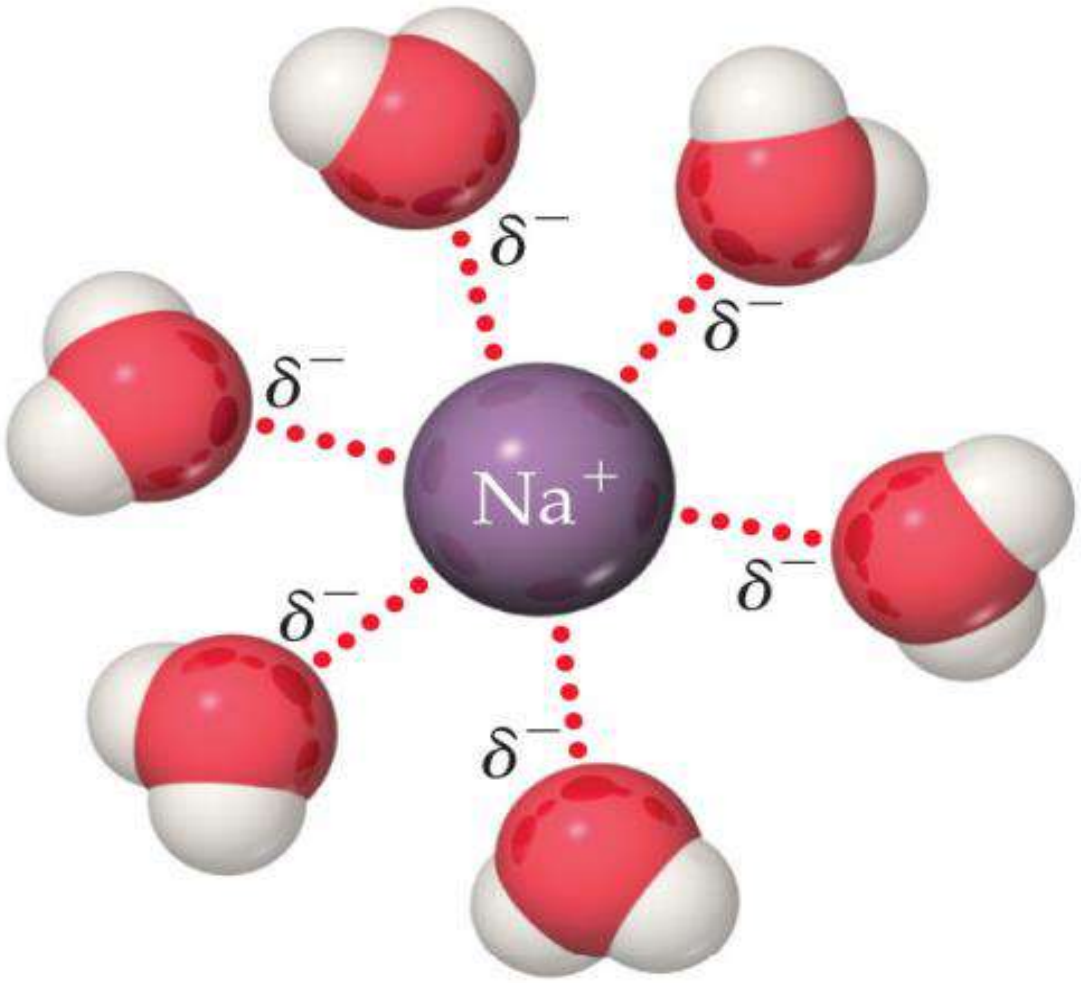
  When an ionic compound, sodium chloride is dissolved in water, the ions get separated and surrounded by water molecules which is called **Hydration** of sodium ions.

Cl^- ion (Cation) – H_2O interaction

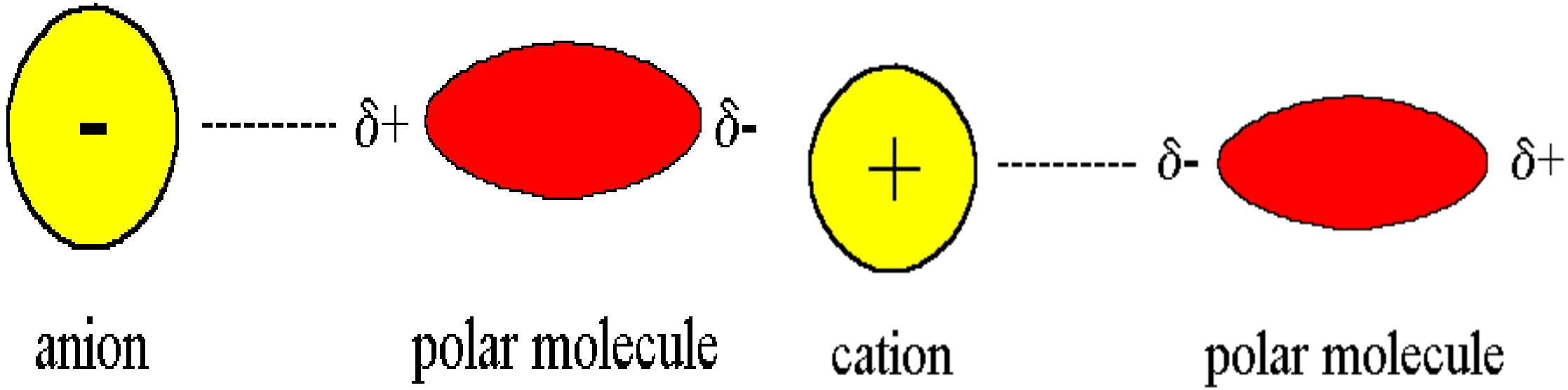


Positive ends of polar molecules

Na^+ ion (Cation) – H_2O interaction



Negative ends of polar molecules



- Strength of Ion – Dipole Interaction depends on two factors:

  1. Magnitude of Dipole moment of polar molecule.

  2. Size and Charge of an Ion.

- **Smaller the size of Ion Greater will be the interaction.**
- **More the concentrated charge on ion greater will be the interaction**
- **Example:**

  Na^+ ion (Cation) – H_2O interaction

  Mg^{2+} ion (Cation) – H_2O interaction

  Al^{3+} ion (Cation) – H_2O interaction

4. Ion – Induced dipole Interaction:

- It is observed between Ion (Cation or Anion) & Non - Polar molecule.
- It is a Temporary Interaction.
- It is defined as the force of attraction exerts between Ion (Cation or Anion) and Non polar molecule having permanent zero dipole moment.
- Examples: Fe^{2+} ion (Cation) – Oxygen molecule.

Ion-induced Dipole



Ion-induced dipole force

5. Instantanous dipole – Induced dipole Interaction:

- It is observed between Atoms (Inert gases) & Non - Polar molecule having zero dipole moment.
- It is a Weakest Interaction.
- It is defined as the force of attraction formed between atoms (inert gases) or Non polar molecules are called Instantanous dipole – Induced dipole Interaction.
- Examples: Cl_2 – Br_2 molecules , Ne – Ne Atoms , Methane molecules.

NOTE:

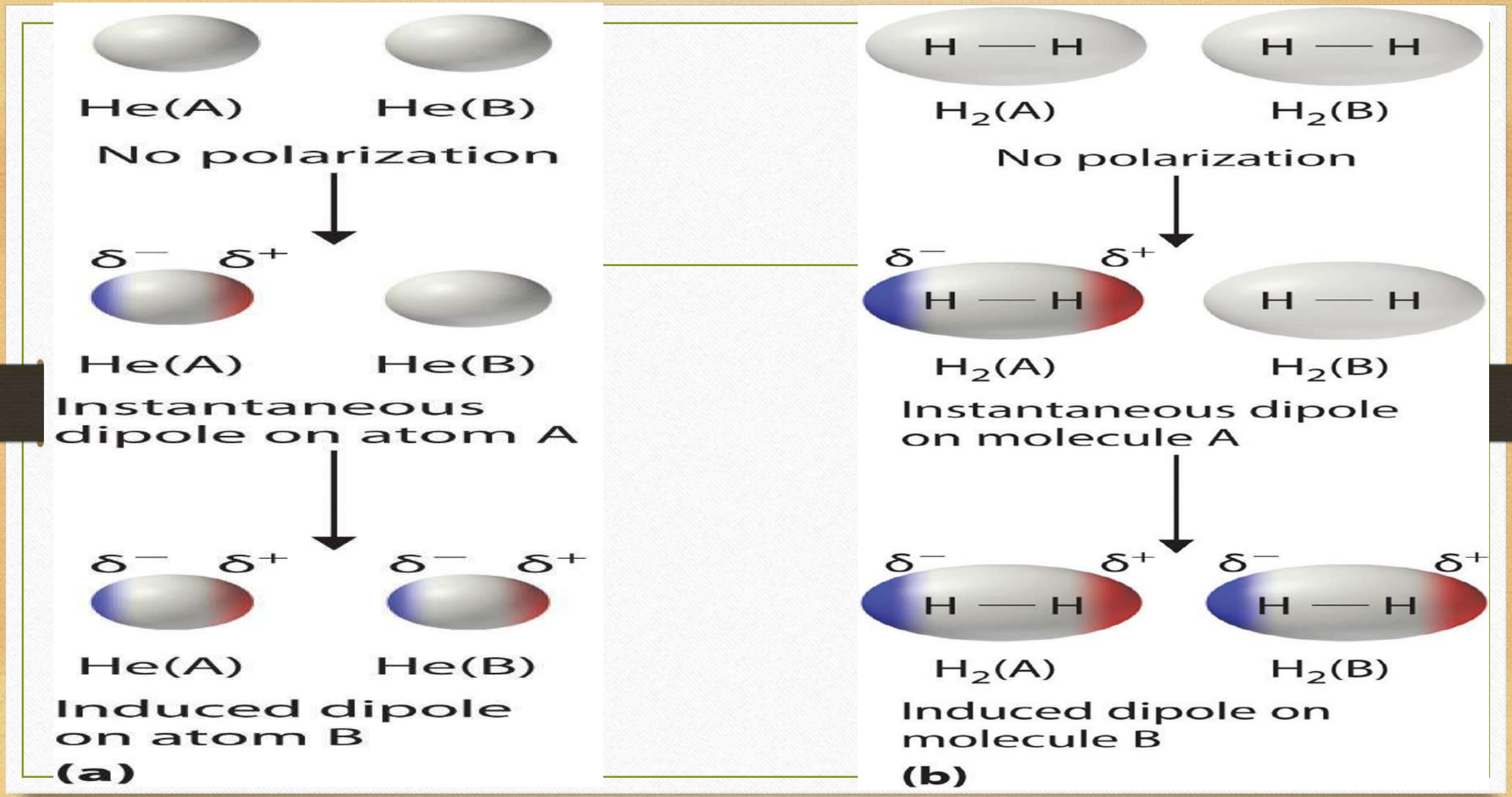
Polarizability:

The ability to form momentary dipoles that means the ability of another molecule to become polar by redistributing its electrons is known as polarizability of the atom or molecule.



Explanation:

- For an Atom/Molecule with nucleus at the centre and electrons are revolving around it by applying electric field the arrangement of electrons in atom/molecule gets disturbed for a fraction of second dipole is produced. Hence it is called as Instantaneous dipole moment.
- The Instantaneous dipole may induce temporary dipole in neighbouring atom/molecule.
- The interaction with instantaneous dipole and induced dipole produce **dispersion force**.
- Such forces are also known as **London force.**


He(A)
He(B)
No polarization
δ− δ+
He(A)
He(B)
Instantaneous dipole on atom A
δ− δ+ δ− δ+
He(A)
He(B)
Induced dipole on atom B
(a)
H — H
H — H
H2(A)
H2(B)
No polarization
δ− δ+
H — H
H — H
H2(A)
H2(B)
Instantaneous dipole on molecule A
δ− δ+ δ− δ+
H — H
H — H
H2(A)
H2(B)
Induced dipole on molecule B
(b)

Strength of London force depends on

a) Molecular Size
b) Atomic Size
c) Molecular mass
d) No of electrons present in an Atom or Molecule.

Instantanous dipole – Induced dipole Interaction

OR

London force

OR

Dispersion force

NOTE : ALL WEAK INTERMOLECULAR FORCES ARE CALLED AS VANDER WAALS FORCES

STRONG FORCE

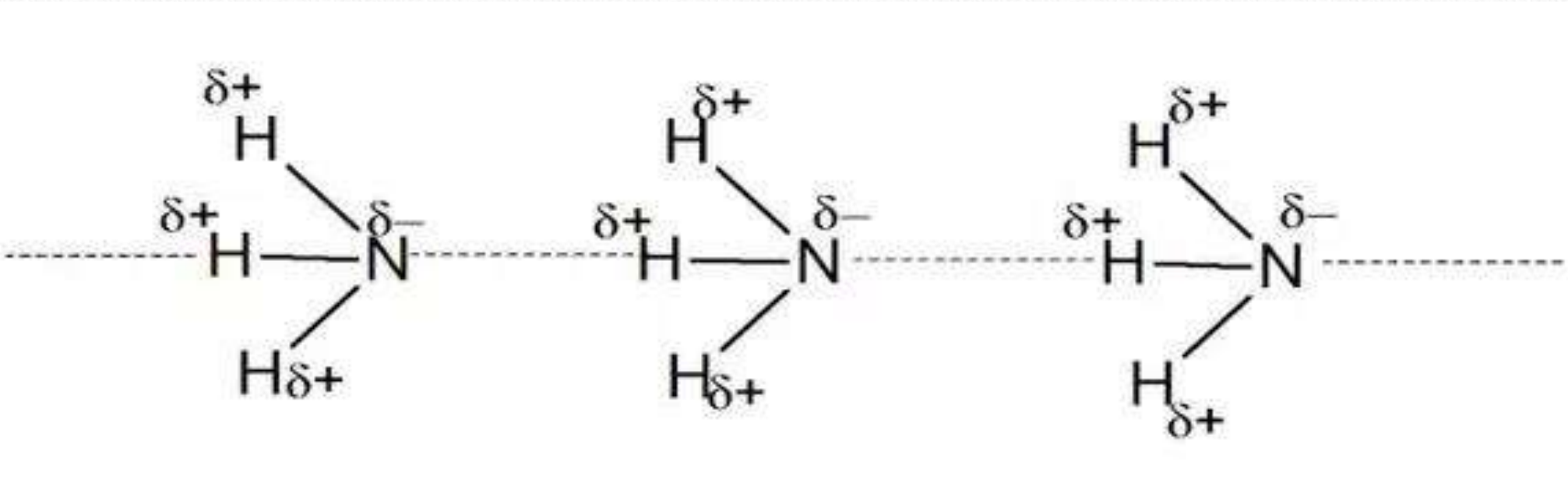
Hydrogen bonding:

- It is observed between Hydrogen atom and Most electronegative atoms such as Fluorine, Oxygen Nitrogen.

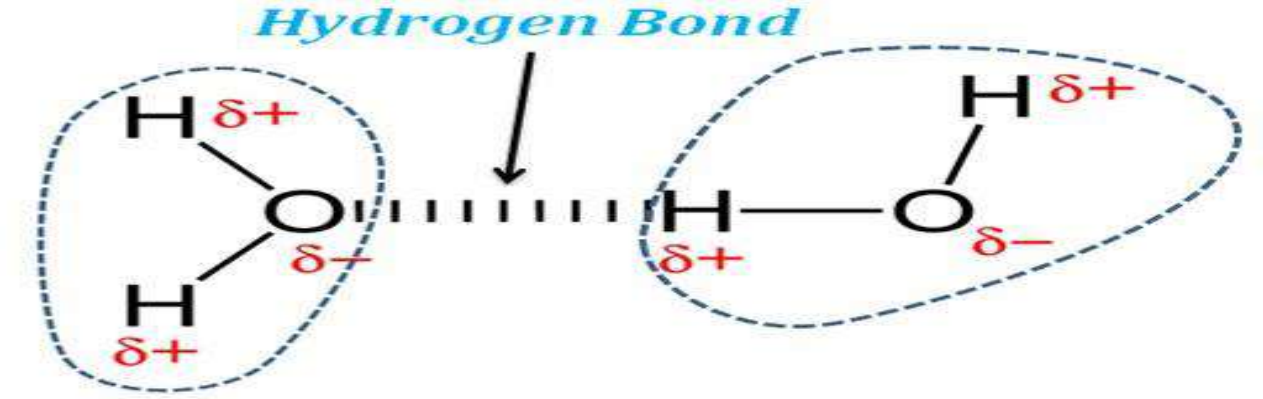
- The electrostatic force of attraction between **positively polarized hydrogen atom of one molecule** and a highly **electronegative atom (which may be negatively charged)** of **other molecule** is called as hydrogen bond.

- A hydrogen bond is a special kind of Dipole-Dipole interaction.
- Hydrogen bonds are generally stronger than usual dipole-dipole and London forces and weaker than true covalent or ionic bonds.
- **Examples:**

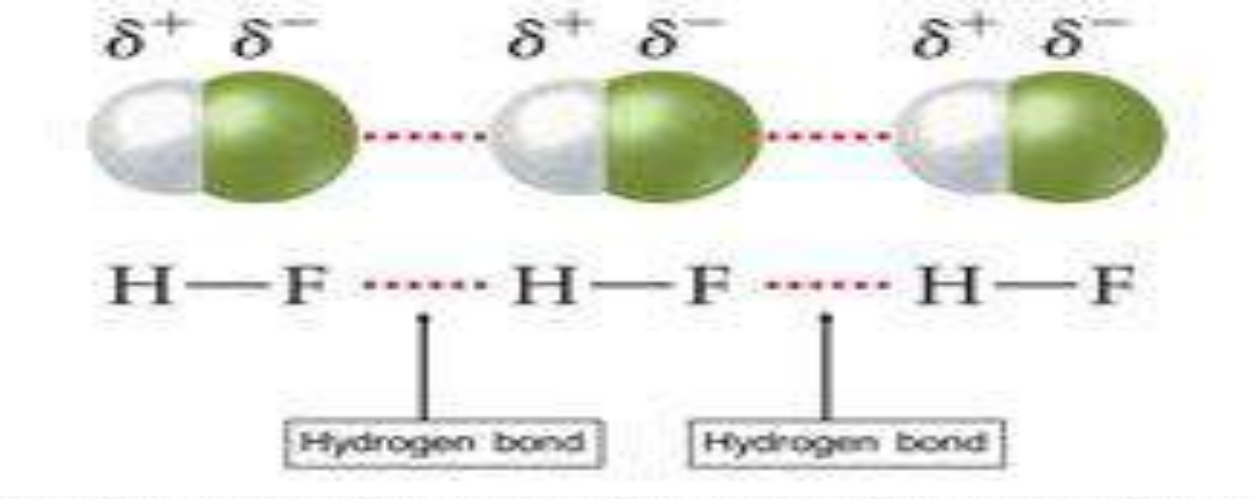
1. Ammonia Molecule



2. Water Molecule



3. Hydrogen fluoride Molecule

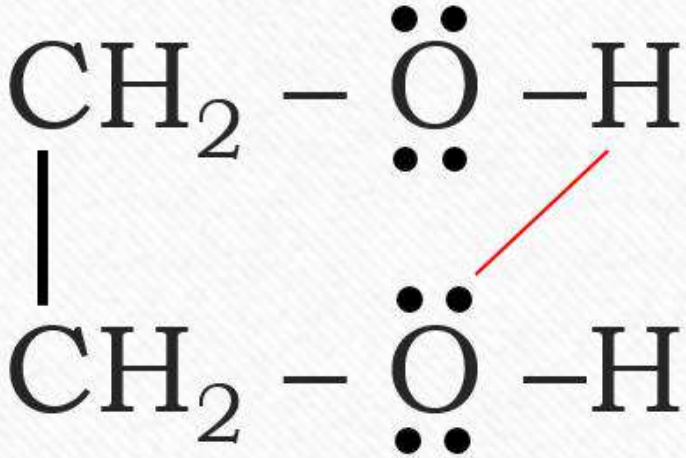


- Hydrogen bonding are of Two types,

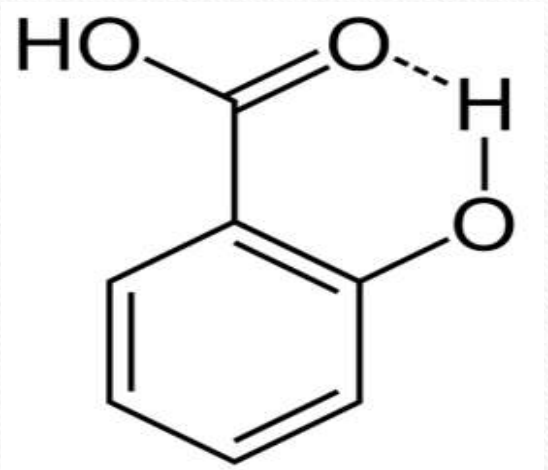
a) INTRAMOLECULAR HYDROGEN BONDING:

Hydrogen Bond which occurs within one single molecule represents Intramolecular hydrogen bonding.

Example : **1.** Ethylene Glycol



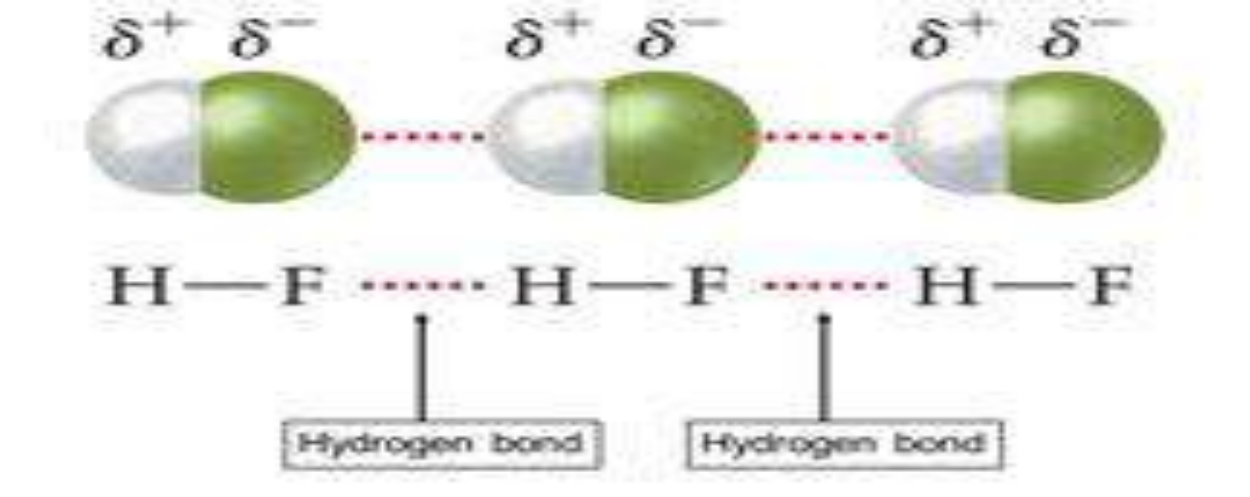
2. 2 – Nitro phenol

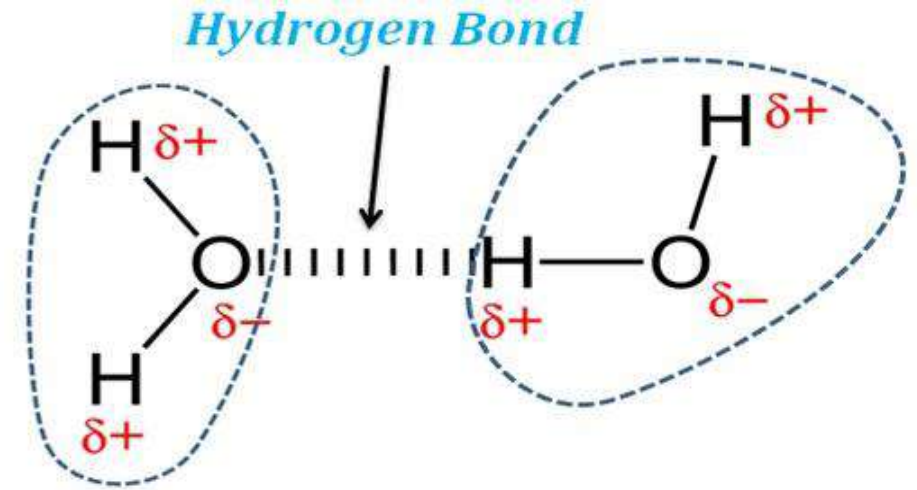


b) INTERMOLECULAR HYDROGEN BONDING:

Hydrogen Bond present between two similar or different molecules represents Intermolecular hydrogen bonding.

Examples:





Types of Intermolecular Forces and Relative Strengths



strongest

Ion-Dipole

Hydrogen bonding

Dipole-dipole

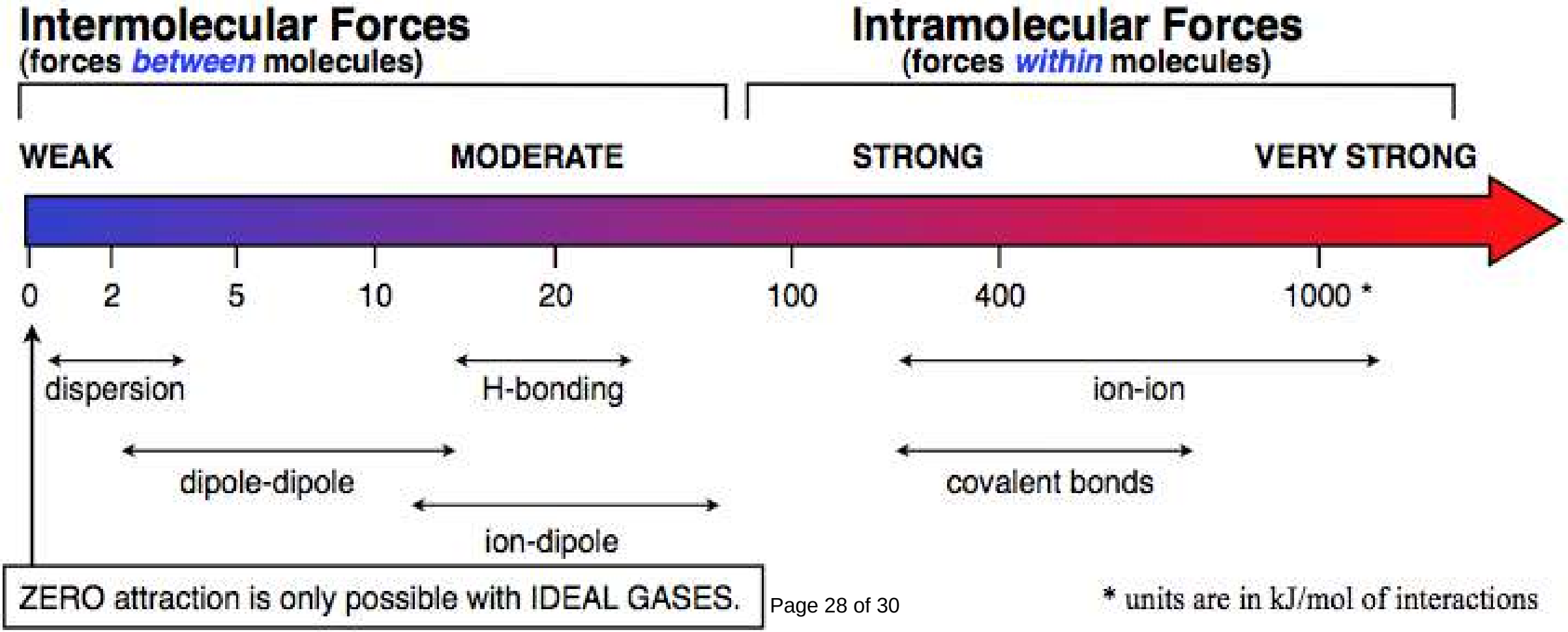
Dipole-induced dipole

weakest

Dispersion forces (or London forces)

Intermolecular and Intramolecular Forces

Do realize in the following diagram that dispersion forces are capable of much more when the molecule containing them increases in size. Polarizability will increase considerably with a molecule's surface area (size). One should always access what the conditions are as to which force is the governing force and what its magnitude is.



* units are in kJ/mol of interactions

EXERCISE

Identify the type of Intermolecular forces of the following compounds

1. $CH_3 – OH$ - Hydrogen bonding as well as London force
2. $CH_2 = CH_2$ - London forces (Between non – polar molecule)
3. $CHCI_3$ - Dipole – Dipole Interaction
4. CH_2Cl_2 - Dipole – Dipole Interaction
5. Cl_2 and CBr_4 - London forces
6. SiH_4 molecules - London forces
7. He atoms in liquid He - London forces
8. HCl molecules in liquid HCl – Dipole – Dipole Interaction
9. He and polar molecule – Dipole – Induced dipole interaction


THANK
YOU