Liquid State

Lecture-1

Rifat Bin Amin

Dept. of Biochemistry

National Institute of Science & Technology

INTERMOLECULAR FORCES IN LIQUIDS

Intermolecular forces in liquids are collectively called van der Waals forces. These forces are essentially electrical in nature and result from the attraction of charges of opposite sign.

The principal kinds of intermolecular attractions are :

(1) Dipole-dipole attractions

(2) London forces

(3) Hydrogen bonding.

DIPOLE–DIPOLE ATTRACTIONS:

Dipole-dipole attractions exist between molecules that are polar. This requires the presence of polar bonds and an unsymmetrical molecule. These molecules have a permanent separation of positive and negative charge.

In the illustration the H and of HCl is permanently slightly positive charge. The Cl end of HCl has a permanent slight negative charge. The H atom in one molecule is attracted to the Cl in a neighbor. The intermolecular force is weak compared to a covalent bond, but this dipole-dipole interaction is one of the stronger intermolecular attractions.

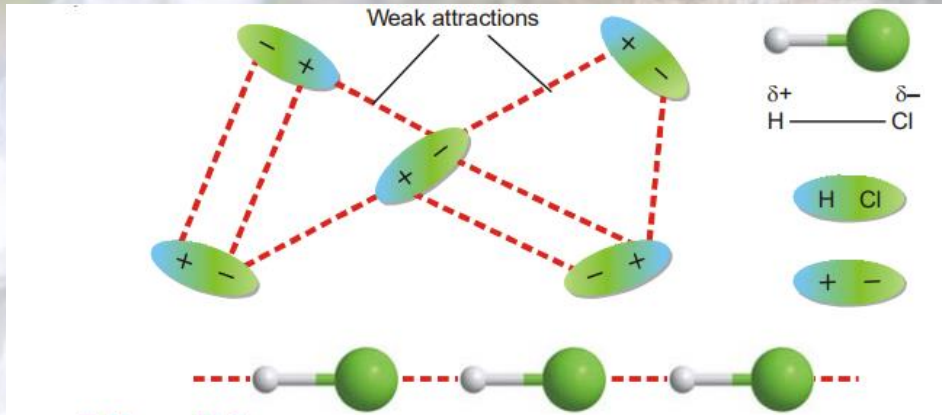


Figure 11.2
Weak attractions between polar HCl molecules.

LONDON DISPERSION FORCES

London dispersion forces exist in nonpolar molecules. These forces result from temporary charge imbalances.

The temporary charges exist because the electrons in a molecule or ion move randomly in the structure.

The nucleus of one atom attracts electrons form the neighboring atom. At the same time, the electrons in one particle repel the electrons in the neighbor and create a short lived charge imbalance.

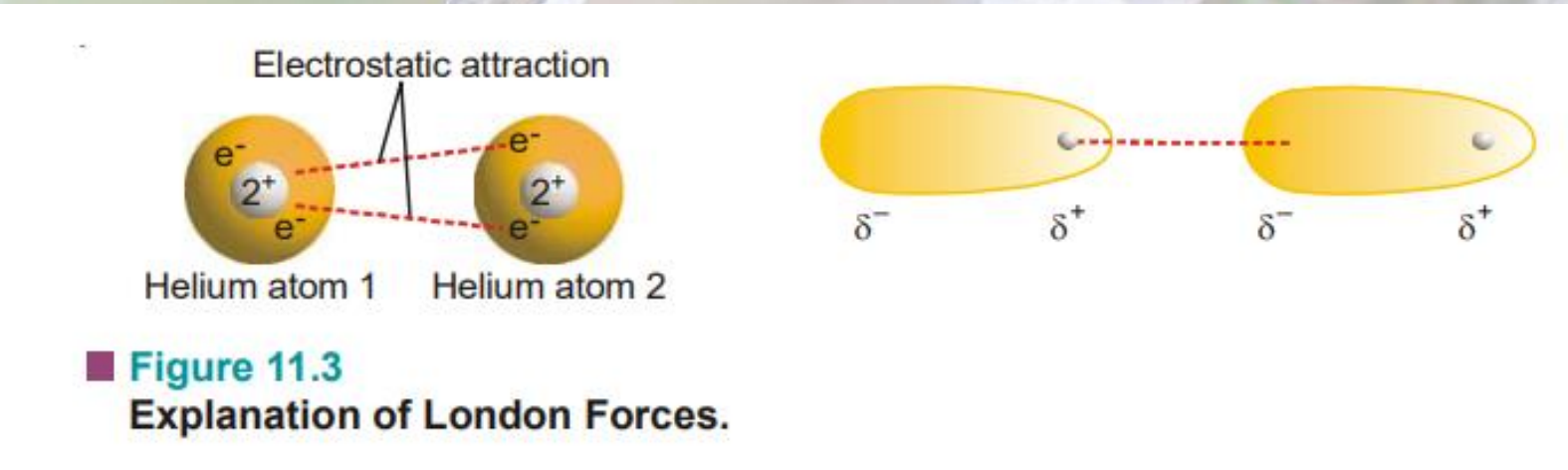


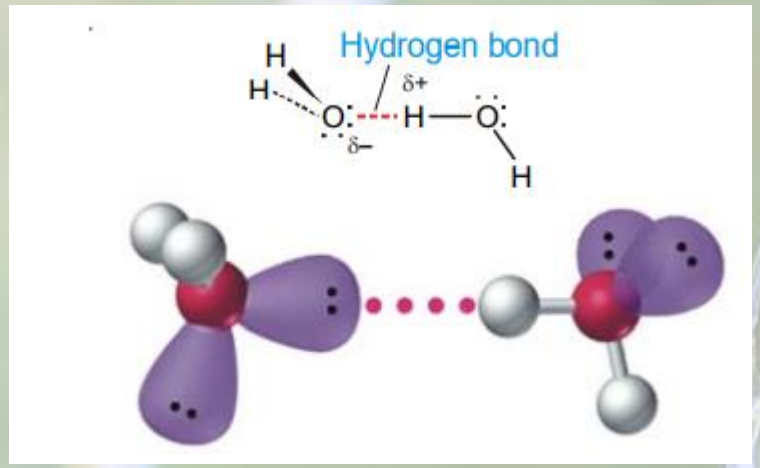
Figure 11.3
Explanation of London Forces.

These temporary charges in one molecule or atom attract opposite charges in nearby molecules or atoms. A local slight positive charge δ+ in one molecule will be attracted to a temporary slight negative charge δ– in a neighboring molecule.

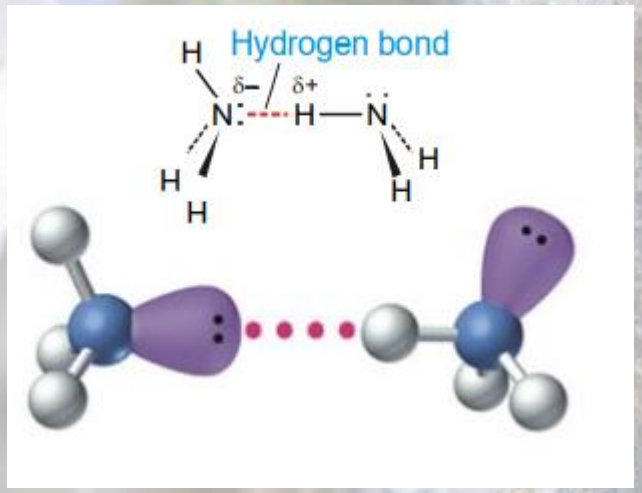
HYDROGEN BONDING

Hydrogen bonding is a unique type of intermolecular attraction.

There are two requirements:
(1) Covalent bond between an H atom and either F, O, or N. These are the three most electronegative elements.
(2) Interaction of the H atom in this kind of polar bond with a lone pair of electrons on a nearby atom like F, O, or N.



Hydrogen bonding in water.



Hydrogen bonding in ammonia.

Hydrogen bonding is responsible for the expansion of water when it freezes. The water molecules in the solid state have tetrahedral arrangement for the two lone pairs and two single bonds radiating out from the oxygen. The lone pairs on the “O” atom can be attracted to nearby water molecules through hydrogen bonds. A cage like structure results.

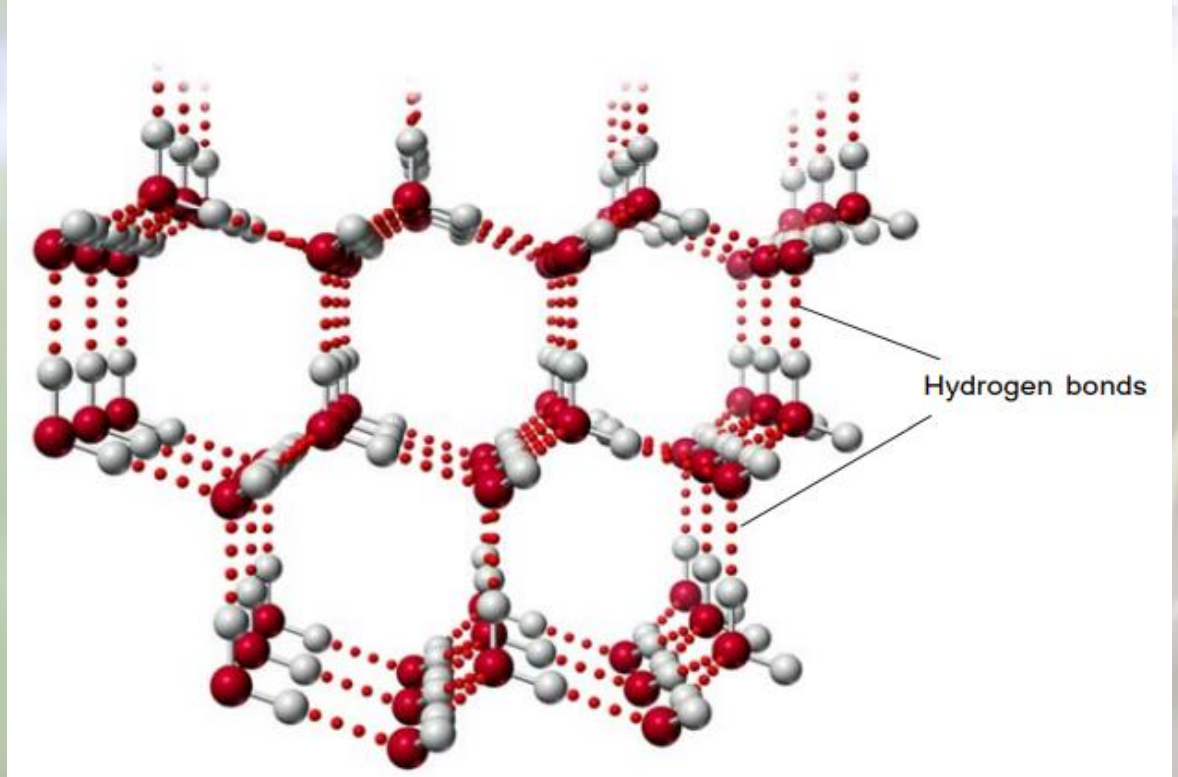


Figure 11.7
Hydrogen bonding in ice.

VAPOUR PRESSURE

When a liquid is placed in an open vessel, it evaporates. The molecules in the liquid are moving with different kinetic energies. The molecules that possess above-average kinetic energies can overcome the intermolecular forces that hold them in the liquid. These energetic molecules escape from the liquid surface as vapour.

Vaporisation or Evaporation:

The process by which molecules of a liquid go into the gaseous state (vapours) is called Vaporisation or Evaporation.

The reverse process whereby gas molecules become liquid molecules is called Condensation.

Liquid → Vapour