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STATE OF MATTER

INTRODUCTION

Any substance that has mass and occupies space is called Matter. Matter is composed of atoms or molecules. The arrangement of these building blocks gives matter various states, physical and chemical properties. The force of interaction between these particles give matter its physical properties based on which matter can be classified into solid, liquid or gases. The force of interaction between atoms/ molecules is **highest in solids and least in liquids**.

In this unit, we will learn more about these three physical states of matter particularly liquid and gaseous states.

1. INTERMOLECULAR FORCES

The forces of attraction existing among the molecules of a substance (gaseous, liquid or solid) are called intermolecular forces.

Dipole-dipole, dipole-induced dipole and dispersion forces are collectively called as van der Waals forces. Ion-dipole and ion-induced dipole forces are not van der Waals forces. Further, hydrogen bonding is only a special type of dipole-dipole attraction shown only by limited number of elements.

The different types of intermolecular forces are :

1.1 Dipole-Dipole Interactions

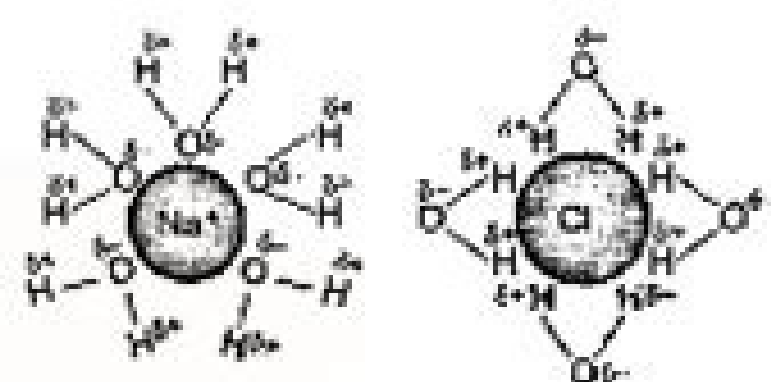
These forces of attraction occur among the polar molecules. Polar molecules have permanent dipoles. The positive pole of one molecule is thus attracted by the negative pole of the other molecule.

HCl in which chlorine being more electronegative acquires a slight negative charge whereas the hydrogen end becomes slightly positively charged. The dipole-dipole interactions then take place among the HCl molecules :



1.2 Ion-Dipole Interactions

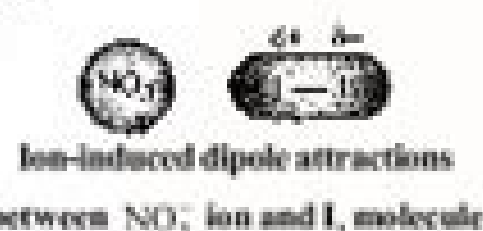
This is the attraction between an ion (cation or anion) and a polar molecule. For example, when NaCl is dissolved in water, the polar water molecules are attracted towards Na^+ ion as well as towards Cl^- ion.



Ion-dipole attractions between Na^+ and H_2O molecules and Cl^- ion and H_2O molecules

1.3 Ion-Induced Dipole Interactions

A non-polar molecule may be polarized by the presence of an ion near it, i.e., it becomes an induced dipole. The interactions between them are called ion-induced dipole interactions.



For example, in the presence of nitrate ion (NO_3^-), iodine molecule (I_2), which is non-polar, gets polarized as $\left(\overset{\delta+}{\text{I}} - \overset{\delta-}{\text{I}} \right)$ as shown in fig.

1.4 Dipole-Induced Dipole Interactions

A non-polar molecule may be polarized by the presence of a polar molecule (dipole) near it, thereby making it an induced dipole. The interactions between them are then called dipole-induced dipole interactions.



For example, noble gases get polarized in the presence of polar molecules.

1.5 London forces or Dispersion forces

At any instant of time, the electron cloud of the molecule may be distorted so that an instantaneous dipole or momentary dipole (i.e., a dipole for a short while) is produced in which one part of the molecule is slightly more negative than the rest. The momentary dipoles induce dipoles in the

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