Matter exists in three different physical states, namely solid, liquid and gaseous states. The three states mainly differ in the arrangement of particles and the force of attraction among the constituent particles.

## Intermolecular Forces

The forces of attraction and repulsion existing among molecules of a substance are called intermolecular forces. The intermolecular forces arise mainlydue to any one of the following interactions.

(i) Dipole – dipole (ii) dipole – induced dipole (iii) Dispersion forces

(iv) Ion – dipole (v) Hydrogen bonding.

Attractive intermolecular forces due to dipole – dipole, dipole – induced dipole and dispersion forces are collectively called **van der Waals forces.**

### (i) Dipole – dipole interactions

These type of interactions occur in polar molecules having permanent dipoles such as *HCl*, *HBr*, $H_2S$ etc. Such molecules possess partial charges of opposite sign at their ends. The positive end of one molecule attracts the negative end of the other molecule and vice versa. A simple example is that of $H - Cl$ in which chlorine being more electronegative acquires slight negative charge whereas hydrogen becomes slightly positively charged. The dipole–dipole interaction then takes place in $H - Cl$ as follows:

$$\overset{\delta+}{H}-\overset{\delta-}{Cl} \qquad \overset{\delta+}{H}-\overset{\delta-}{Cl} \qquad \overset{\delta+}{H}-\overset{\delta-}{Cl}$$

The interaction energy is proportional to $1/r^3$ between stationary polar molecules and proportional to $1/r^6$ between rotating polar molecules, where $r$ is the distance between two molecules.

### (ii) Dipole – induced dipole interactions

These type of interactions are found in a mixture, containing polar and nonpolar molecules.

When a nonpolar molecule is brought near a polar molecule, the positive end of the polar molecule attracts the electron cloud of the nonpolar molecule. Thus a polarity is induced in the nonpolar molecule. Then there will be attractive interaction between the polar molecule and the induced dipole of the nonpolar molecule. This type of forces are found to operate in a mixture of *HF* and $O_2$ , *HCl* and $N_2$ etc.

This interaction energy is also proportional to $1/r^6$ , where $r$ is the distance between two molecules.