EC-⑧

Subject : PHYSICS
Topic : Van der Waal Bonding
Class : TDC–III, Paper–VI, Group – 'A'
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Ans. Van der Waal bonding. The atoms of inert gases like those of *He* and *Argon* are spherically symmetrical and have no valence electron, as their outermost electron orbits are completely filled. They are, therefore, incapable of forming any bond. Also certain organic molecules like CH_4 and molecules containing atoms of halogens, oxygen, nitrogen, sulphur, phosphorous have the bonding capacity of all constituent atoms satisfied and the outer orbits of all these atoms in the molecules attain inert gas configuration. However, these molecules condense to liquid and solid state with a decrease of energy. To explain this, Van der Waal suggested some type of attractive force between these molecules and atoms of inert gases. These are weak attractive forces which become relatively stronger in the liquid or solid states. The Van der Waal attraction between two molecules, a distance r apart, is proportional to r^{-7} so that it is significant only f molecules very close together. Thus Van der Waal force is a short range force falling rapidly as th atoms separate.

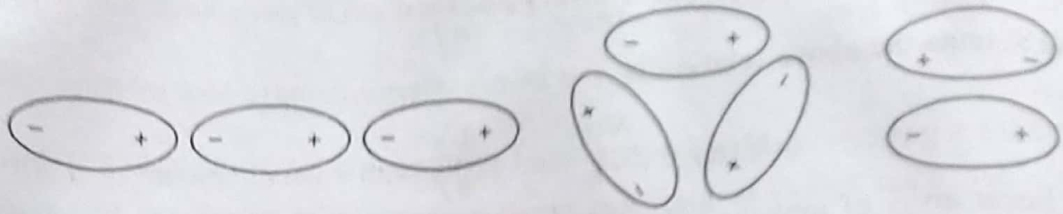

Fig. 3.4

To explain the mechanism of these weak attractive forces, let us first consider *polar molecule* *i.e.*, those molecules which have a permanent electric dipole moment of which H_2O molecule is a example. In H_2O, the concentration of electrons around the oxygen atom makes that end of th molecule more negative than the end where the hydrogen atoms are. Such molecules tend to alig themselves with ends having opposite kind of charge adjacent to each other because in th orientation the molecules strongly attract each other as shown in Fig. 3.4.

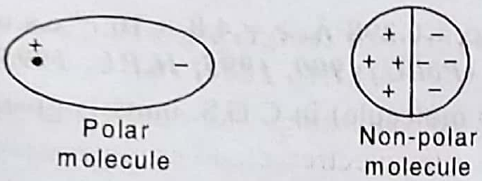

Fig. 3.5

Let us next consider a *polar* and a *non-polar* molecu as shown in Fig. 3.5. The electric field of the polar molecu causes a separation of charge in the other (non-polar molecule so that the positive charge lies nearer to the negativ end, thus resulting in an attractive force.

Even two *non-polar* molecules can attract each other b the above process. Suppose two non-polar molecules are extremely close to each other. The nucle and the electrons of these atoms are in ceaseless motion. It may be imagined that the electron clou may be concentrated at one end of the atom or molecule at a certain moment and a fraction of second later, it may be located at the other end of the atom or molecule. This instantaneou concentration of the electron cloud sets up a temporary dipole called the *instantaneous dipole*. Th energy of the system is decreased by an attractive interaction between two such instantaneou dipoles. The dipole in atom *A* induces a similar dipole in the adjacent atom *B* as shown in Fig. 3.6 and the electron cloud shifts to the other side, pulling back the electron cloud in *B*. These temporar dipoles, both oriented in the same direction, lead to an attractive force between the atoms o molecules. These forces arise from the fact that the electrons in adjacent atoms or molecules ar oscillating to produce fluctuating dipoles which produce immediate attraction with the decrease of energy of the system. Thus Van der Waal forces are caused by dipole-dipole and dipole-induced dipole interaction. These forces depend upon the following factors:

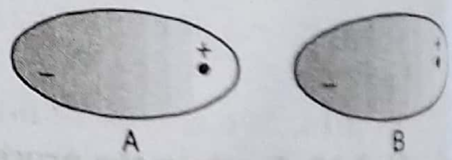

Fig. 3.6

(i) *Number of electrons present in the molecule*. The forces increase with the increase i number of electrons in a molecule.

(ii) *Molecular size*. The larger the molecular size, greater will be the surface area and stronge is the Van der Waal interaction.

(iii) *Effect of pressure*. If the pressure is increased, the molecules are pressed together, resultin in a stronger attraction.

(iv) *Condition of temperature*. Lower the temperature lesser is the movement of the molecule and stronger the molecular interactions and hence greater is Van der Waal force.

Van der Waal bonds are the weakest. Van der Waal bond arises due to some type of attractiv force between the molecules or the atoms of inert gases. This is a very weak force as Van der Wa attraction between two molecules a distance r apart is proportional to r^{-7}. As such it is significant only for molecules very close together. This is a *short range* force falling rapidly as the atoms separate. Because of this *short range, weak force*, Van der Waal bond is very weak.

Physical characteristics of inert gas crystals. Inert gas crystals have Van der Waal bonding. Their characterisation are:

(*i*) As Van der Waal force is weak, the inert gas crystals have low melting and low boiling points.

(*ii*) The inert gas crystals change their state easily with a small amount of thermal energy.

(*iii*) Van der Waal forces in inert gas crystals give rise to properties like friction, surface tension, viscosity, cohesion, adhesion etc.

(*iv*) Due to Van der Waal forces, there is always a difference between the pressure exerted by a real gas and that of an ideal gas.

(*v*) The inert gas crystals usually adopt cubic close packed *fcc* structure except He^3 and He^4. These crystals are insulators and are transparent to electromagnetic radiation down to ultraviolet range.

(*vi*) The inert gas crystals are brittle and lack strength.

(*vii*) The inert gas crystals have very high ionisation energy.