1.11 Effective Mass (m*)

- It is presumed that mass of free electron is same as that of electrons of combining atoms which form a solid.
- But, experimentally it is observed that, mass of electron in some solids is less and in some solid, it is larger than the mass of free electron.
- **The experimentally determined electron mass in solid is called as effective mass** and is represented by **m***.
- **Change in the mass of electron in solids is due to interaction between atoms in solids and drifting of electrons.**

1.12 Semiconductors

- The materials having electrical conduction greater than insulator and less than conductors are called as semiconductors.
- These materials have a valence band almost filled and conduction band almost empty. The conduction band and valence band are separated by a small energy gap of $E_g \approx 2eV$.
- Semiconductors are of Two Types :
  1) **Intrinsic** Semiconductors
  2) **Extrinsic** Semiconductors.

Intrinsic or Pure Semiconductors :

- The materials in their pure form exhibiting properties of semiconductors are known as **Intrinsic** or **Pure Semiconductors**. e.g. Si and Ge.

- The pure semiconductor atoms are tetravalent in nature i.e. capable forming 4 covalent bonds with other atoms, as outermost shell of semiconductor atoms consist of four electrons.
- Semiconductor atom forms 4 covalent bonds with the neighbour atoms by sharing 4 electrons to achieve a stable structure as shown below.

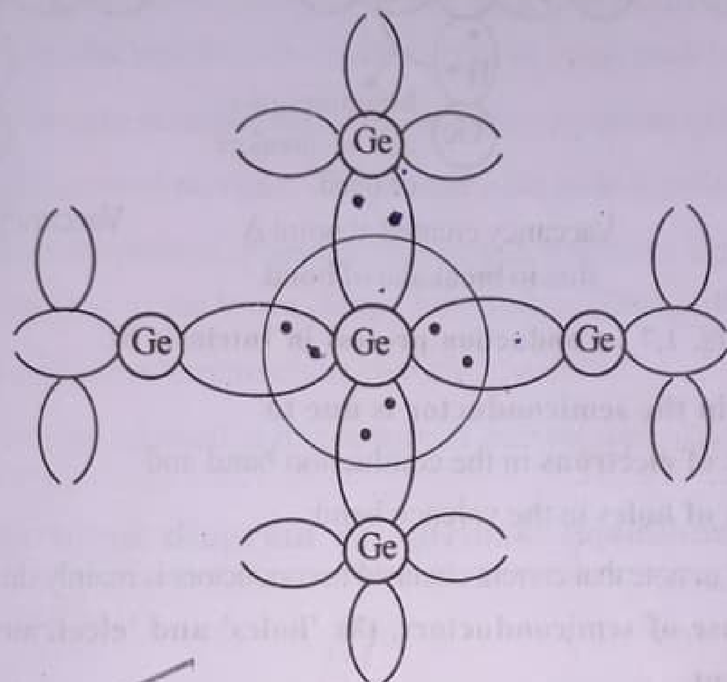


Fig. 1.6 : Tetravalent nature of Semiconductor atom

1.12.1 Conduction Process in Semiconductors

- At room temperature, the bonds between few semiconductor atoms break due to available thermal energy.
- When bonds are broken, electrons in the valence band acquire additional energy and jump to the higher level conduction band region.
- Electrons in the conduction band region act as free electrons and are available for electrical conduction process.
- When electron jumps from valence band to the conduction band, an empty space is left behind in the valence band.
- As this empty space is created due to removal of one -ve charge, it is treated as a +ve charge and is known as '**hole**'.
- The vacancy gets filled when electron from another bond occupy it.
- As a result vacancy is created at another place as shown in Fig. (1.7).
- In this way, position of vacancy changes within the crystal.
- In other words, 'hole' moves from one position to the other within crystal.
- The 'hole' being +vely charged particle, its movement causes an electrical current.

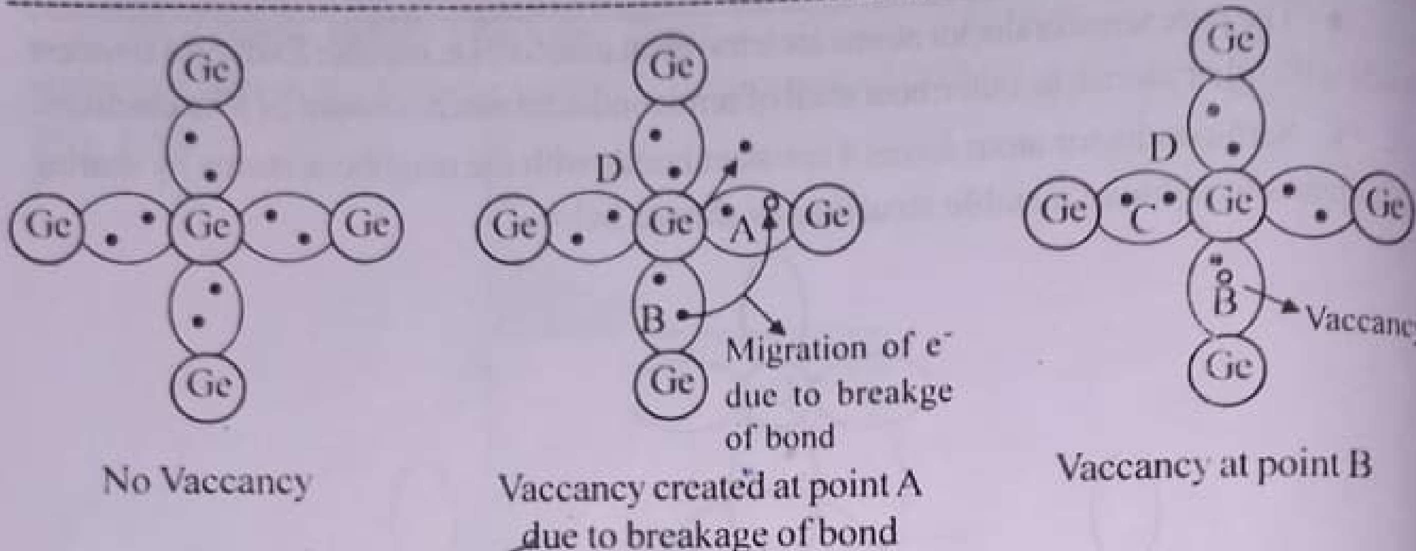


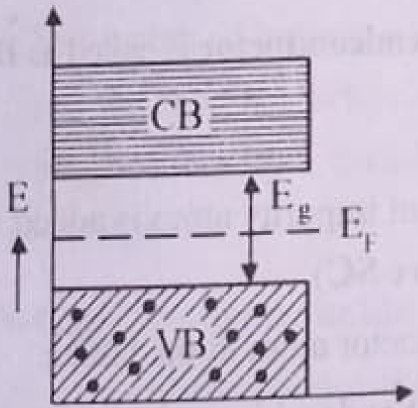
Fig. 1.7 : Conduction process in Intrinsic SC

- **So, current in the semiconductor is due to**
  (i) **mobility of electrons** in the conduction band and
  (ii) **mobility of holes** in the valence band.

- It is important to note that current obtained in conductors is mainly due to movement of electrons but **in case of semiconductors, the 'holes' and 'electrons' contribute equally for the current.**

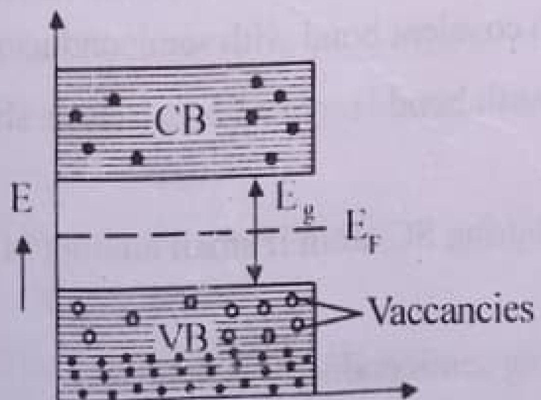
1.13 Energy band diagram of Intrinsic Semiconductor

(1) At $T = 0^0 K$



- At absolute zero temperature, the bonds between semiconductor atoms are intact.
- Therefore, valence band is almost filled.
- Conduction band is totally empty.
- No charge carriers in CB.

(2) At $T > 0^0 K$



- Thermal energy available breaks bonds between few semiconductor atoms releasing electron-hole pairs.
- Free electron gains energy and jumps to conduction band. Conduction band is therefore, partially filled.
- Transfer to of electron to conduction band leaves vacancy in the valence band.