

15) of Give the salient features of BCS theory of superconductors.

a) The microscopic theory put forward by Bardeen, Cooper and Schrieffer (BCS), in 1957, provides the better quantum explanation of superconductivity and accounts very well for all the properties exhibited by the superconductors. Some of the salient features of BCS theory are the following.

i) Electron-lattice-Electron interaction:

BCS showed that the basic interaction responsible for superconductivity appears to be that of a pair of electrons by means of an interchange of virtual phonons.

The two electrons interact. Suppose an electron approaches a positive ion core. It suffers attractive coulomb interaction. Due to this attraction, ion core is set in motion and consequently distorts the lattice.

Suppose towards that side another electron comes and sees this distorted lattice.

Then the interaction between the two electrons and the distorted lattice occurs which in its effect lowers the energy of the second electron. Thus we interpret that the two electrons interact via the lattice distortion or the phonon field resulting in the lowering of energy for the electrons. This type of interaction is called electron-lattice-electron interaction.

ii) Cooper pair: - The fundamental postulate of BCS theory is that the superconductivity occurs when an attractive interaction between two electrons, by means of a phonon exchange, dominates the usual repulsive coulomb interaction. Two such electrons which interact attractively in the phonon field are called a Cooper pair.

The energy of the pair of electrons in the bound state is less than the energy of the pair in free state. The difference of the energy of the two states is the binding energy of the Cooper pair. At temperatures less than critical temperature, electron-lattice-electron interaction is stronger than electron-electron-Coulomb interaction, and so the valance electrons tend to pair up. Pairing is complete at  $T=0K$  and is completely broken at critical temperature.

iii) Existence of energy gap:- The energy difference between the free state of the electron and the paired state appears as the energy gap at the Fermi surface. The normal electron states are above the energy gap and superconducting electron states are below the energy gap at the Fermi surface. Energy gap is a function of temperature. Since pairing is complete at  $0K$ , the difference in energy of free and paired electron states is maximum or in other words energy gap is maximum at absolute zero. At  $T=T_c$ , pairing is dissolved and energy gap reduces to zero.

iv) Coherence length:- The paired electrons (Cooper pairs) are not scattered because of their peculiar property of smoothly riding over the lattice imperfections without ever exchanging energy with them. Consequently, they can maintain their coupled motion upto a certain distance called coherence length.