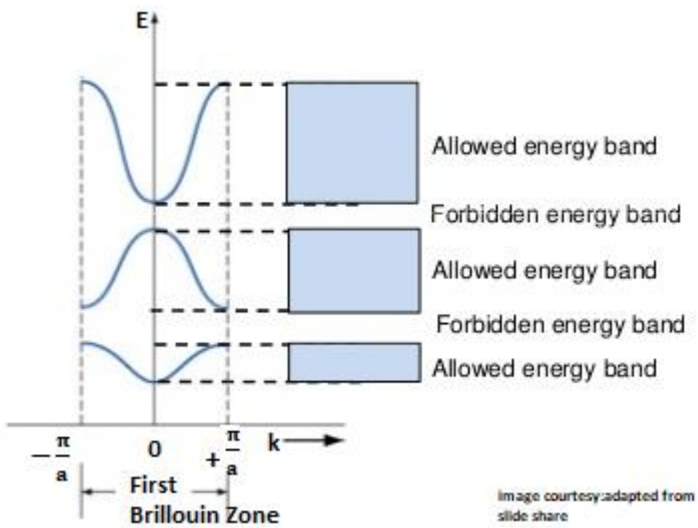
CL32_Q1. Discuss the E-k diagram and give a qualitative picture of the origin of band gaps.

Answer



The Kronig-Penney model assumed the periodic potential in a solid as a long chain of coupled finite square wells, of barrier height Vo, with a period 'a', and barrier thickness 'b'.

The solution to Schrodinger's equation is analyzed using the Bloch theorem, as $\psi(x) = e^{ikx} . V(x)$, where, V(x) is periodic potential, that is $V(x+a) = V(x)$.

Analysis of KP model suggests that solutions are possible only for restricted values of 'E' within certain ranges of the propagation vector 'k' which form the allowed energy bands.

CL32_Q2. Distinguish between conductors, insulators and semiconductors on the basis of band theory of solids.

Answer

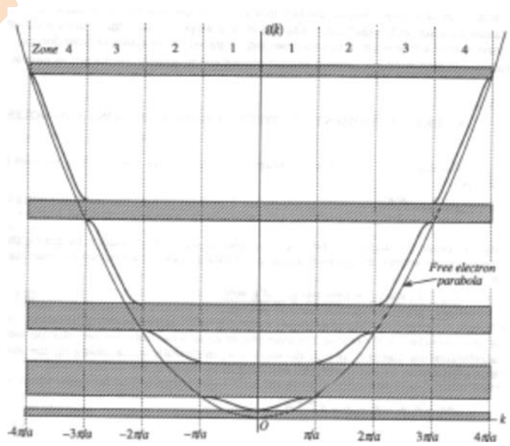
On the basis of band theory in conductors overlapping of the valence and conduction bands with large number of conduction electrons even at low temperatures.

In the case of semi-conductors, the energy gap between the valence band and the conduction band is quite small (3-5 eV). At normal temperatures it is possible for the electrons in the valence band to move into the conduction band.

Insulators possess no effective free electrons, all the bands up to the valence band are completely filled and the conduction band is completely empty with wide forbidden energy region (greater than 5eV) in which the electron conduction is impossible.

CL32_Q3. With the help of E-K plot, show that materials can be classified into conductors, insulators and semiconductors.

Answer



The E(k) –k diagram for the system show discontinuity in the energy at the zone boundary of $k = \pm n\frac{\pi}{a}$.

Since the functions are symmetric, it is possible to represent the energy band diagram in a single zone of $+\frac{\pi}{a}$ **to** $-\frac{\pi}{a}$.

The lowest allowed energy state is non-zero. The lowest band is the completely filled inner band followed by a band of forbidden energy states (shaded).

The next band of allowed states represents the valence band. The upper most occupied states form the conduction band.

Thus we observe allowed and forbidden energy states for the electrons in the material.

Materials are then classified as metals, semiconductors or insulators on the basis of the Fermi energy of the material.

In the case of conductors the Fermi level is in the uppermost band the conduction band. All states below the Fermi level are filled and all levels above the Fermi energy are empty. Thus metal are characterized by a partially filled conduction band.

In the case of materials with a completely filled valence band and completely empty conduction band, the Fermi energy is theoretically the midpoint of the energy band gaps. Materials with energy gap of 3-5 eV are classified as semiconductors. At normal temperatures it is possible for the electrons in the valence band to move into the conduction in the case of metals and semiconductors.

Materials with energy band gap greater than 5eV are classified as Insulators in which the electron conduction is impossible and attempts to excite the electrons lead to a dielectric breakdown.