13.KRONIG-PENNEY MODEL

Introduction:

The Kronig - Penney model was introduced in 1931 by L. Kronig and WG. Penney.

- The Kronig-Penney model is a simplified quantum mechanical model that describes an electron in a 1-D periodic potential, yields energy bands as well as energy gaps.

Explanation:

- The free e's in a metal move under a periodic potential due to regularly arranged +vely ions.
- The nature of energies of the electrons is determined by solving Schrodinger wave equation.
- The Kronig-Penney model represents the periodic potential (a+b) in the form of regular arrays of square well potentials as shown in figure.
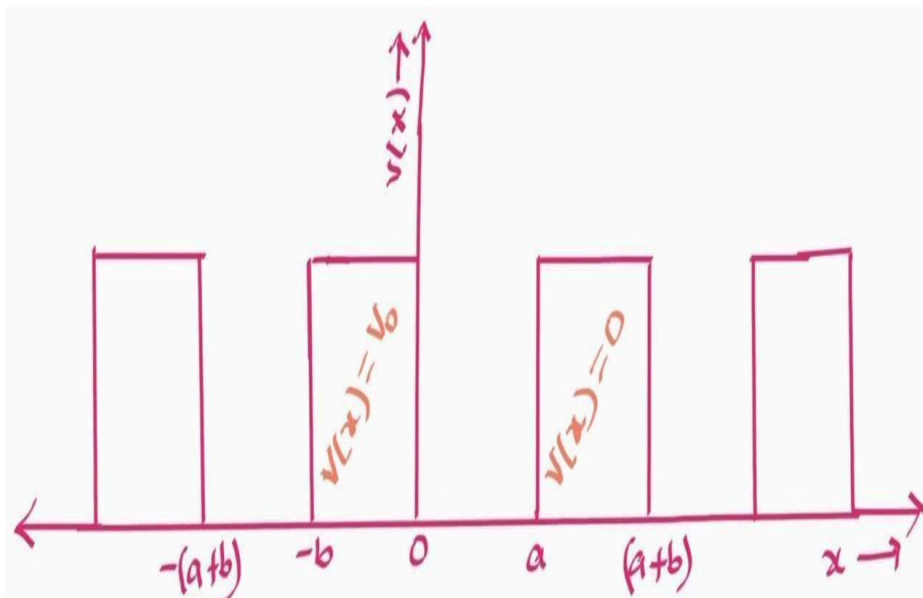
- In a region where 0<x<a, the Potential energy is assumed to be zero.

    V=0 -----------(1)

- In region where -b<x<0, the Potential energy is assumed to be V_0.

    $V=V_0$ ------------(2)

- The Schrodinger wave equation $\partial^2\psi/\partial x^2 + 8\pi^2 m(E-V)\psi/h^2$ for the above two regions are

    $$\partial^2\psi/\partial x^2 + 8\pi^2 mE\psi/h^2 = 0 \text{ ------------------(3)}$$
    $$\partial^2\psi/\partial x^2 + 8\pi^2 m(E-V_0)\psi/h^2 = 0 \text{ -------------- (4)}$$

- From kronig penney model, energy of electron(particle) is given by

    $E = h^2\alpha^2/8\pi^2 m = h^2 k^2/8\pi^2 m$ ------------ (10)

- **Where:** $\alpha = k = n\pi/a$ ----------- (12)

Assumptions made by Kronig and Penney:

- To derive the relationship for the allowed values of electron **energies** during the motion of an electron within a crystal lattice, Kronig and Penney made the following **assumptions**:

    (i)The energy of the electron (E) is less than the potential barrier height (V_0).

    (ii)The solutions to the Schrodinger wave equation are Bloch functions.

    (iii)The wave functions and their first derivatives are continuous throughout the crystal lattice.

Applications of Kronig-Penney Model:

- It is used in the development of semiconductor chips.
- It is used to select the correct material according to the need in the manufacturing of different electronic devices.
- It is used to understand the behavior of material.
- It is used to identify the nature of material.