

Electrical and Thermal Conductivity of Materials

Postulates of Classical free electron theory

- 1) The free electrons of a metal are having like the molecules of a gas in a container.
- 2) The free electrons are free to move in all possible directions about the whole volume of metals but in a particular direction, the resultant velocity of the free electron is zero.
- 3) In the absence of an electric field, the free electrons move in random directions making elastic collisions with no loss of energy.

- 4) When an external field is applied, the free electrons are slowly drifting towards the positive potential.
- 5) Since the electrons are assumed to be a perfect gas they obey classical kinetic theory of gasses.
- 6) Classical free electrons in the metal obey Maxwell-Boltzmann statistics.
- 7) The drift velocity ' v_d ' is the average velocity acquired by the free electron of a metal in a particular direction by the application of the electric field.

- 8) Relaxation time ' τ ' is defined as the time taken by the free electron to reach its equilibrium position from its disturbed position in the presence of electric field.
- 9) The collision time ' τ_c ' is the average time taken by a free electron between two successive collisions.
- 10) For an isotropic solid, like a metal $\tau = \tau_c$.

Advantages of classical free electron theory

- 1) It explains the electrical conductivity and thermal conductivity of metals.
- 2) It explains the Wiedemann - Franz law.
- 3) It verifies Ohm's law.
- 4) It is used to explain the optical properties of metals.

Drawbacks of classical free electron theory

- 1) It fails to explain the electric specific heat and the specific heat capacity of metals.
- 2) It fails to explain superconducting properties of metals.
- 3) It fails to explain new phenomena like photo-electric effect, Compton effect, Black body radiation, etc.
- 4) It fails to explain electrical conductivity of semiconductors or insulators.

- 5) The classical free electron model predicts the incorrect temperature dependence of σ .
- 6) It fails to give a correct mathematical expression for thermal conductivity.
- 7) Ferromagnetism could not be explained by this theory.
- 8) Susceptibility has greater theoretical value than the experimental value.

Thank You