Free Electron Theory

- ✓ **Assumptions**
- ✓ **Success**
- ✓ **Drawbacks**

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Free Electron Theory

Question can be asked like : What are the

Assumptions
Or
Salient features
Or
Postulates

Free Electron Theory

The electron theory of metals aims to explain the properties of materials. The electron theory is applicable to all materials i.e., both metals and non metals. It explains the electrical, thermal and magnetic properties of solids etc.

The classical free electron theory
Drude and Lorentz proposed this theory in 1900. According to this theory, the metals containing the free electrons obey the laws of classical mechanics.

The quantum free electron theory
Somerfield developed this theory in 1928. According to this theory the free electrons obey quantum laws. According to this theory the free electrons are moving in a constant potential.

Assumptions (or salient features) in classical free electron theory

The classical free electron theory is based on the following postulates.

1. The valence electrons of atoms are free to move about the whole volume of the metal, like the molecules of a perfect gas in a container.

2. The free electrons move in random direction and collide with either positive ions fixed to the lattice or the other free electrons. All the collisions are elastic in nature i.e., there is no loss of energy.

3. The momentum of free electrons obeys the laws of the classical kinetic theory of gases.

4. The electron velocities in a metal obey classical Maxwell-Boltzman distribution of velocities.

5. When the electric field is applied to the metal, the free electrons are accelerated in the direction opposite to the direction of applied electric field.

6. The mutual repulsion among the electrons is ignored, so that they move in all the directions with all possible velocities.

7. In the absence of the field, the energy associated with an electron at temperature T is given by $\frac{3}{2}kT$

It is related to the kinetic energy equation $\frac{3}{2}kT = \frac{1}{2}m \; v_{th}^2$

Here V_{th} represents the thermal velocity

Success of Classical Free Electron Theory

1. It verifies ohm's law

2. It explains electrical conductivity of metals.

3. It explains thermal conductivity of metals.

4. It derives Widemann – Franz law. (I.e. the relation between electrical and thermal conductivity.

5. The optical property of metals was explained by this model

Drawbacks of Classical Free Electron Theory.

1. It could not explain the photoelectric effect, Compton Effect and black body radiation.

2. Electrical conductivity of semiconductors and insulators could not be explained.

3. Widemann – Franz law is not applicable at lower temperatures.

4. It fails to explain the specific heat and the specific heat capacity of metals.

5. It fails to explain superconducting property of metals.

6. Ferromagnetism could not be explained by this theory.