

FREE ELECTRON THEORY OF METALS :- (DRUDE THEORY) :-

Drude in 1900, postulated that the metals consist of positive ion cores with the valence electrons moving freely there cores. The electrons are bound to move within the metal due to electrostatic attraction between the positive ion cores and the electrons. The potential field of these ion cores, which is responsible for such an interaction, is assumed to be constant throughout the metal and the mutual repulsion among the electrons is neglected. The behaviour of free electrons moving inside the metal is considered to be similar to that of atoms or molecules in perfect gas. These free electrons are referred to as free electron gas and the theory is accordingly named as free electron gas model.

Firstly, the free electron gas is negatively charged whereas the molecules of an ordinary gas are mostly neutral. Secondly, the concentration of electrons in an electron gas is quite large as compared to the concentration of molecules in an ordinary gas. The valance electrons are also called the conduction electrons and obey the Pauli's exclusion principle. These electrons are responsible for conduction of electricity through metals. Since the conduction electrons move in a uniform electrostatic field of ion cores, their potential energy remains constant and is normally taken as zero i.e the existence of ion cores is ignored.

Thus the total energy of a conduction electrons is ~~related~~ ~~to~~ ~~this~~ equal to its kinetic energy.

Also, since the movement of conduction electrons is restricted to within the crystal only, the potential energy of a stationary electron inside a metal is less than the potential energy of an identical electron just outside it. This energy difference V_0 , serves as a potential barrier and stops the inner electrons from ~~leaving~~ leaving the surface of the metal. Thus, in free electron gas model, the movement of free electrons in a metal is equivalent to the movement of a free electron gas inside a potential energy box, which is 1-D ~~box~~ case.

H.A Lorentz postulated in 1909 that the electrons consisting the electron gas obey Maxwell-Boltzmann statistics under equilibrium conditions.

The combined ideas of Drude and Lorentz constitute the Drude-Lorentz theory. As the based on ~~at~~ Maxwell-Boltzmann statistics, it is called the classical theory.

The theory has been successfully applied to explain the various properties of metals. It proves the validity of Ohm's law. The free electrons in a metal move in random directions and do not constitute a current until an electric field is applied across the metal which accelerates the electrons in a particular direction. The electrons, ~~at~~ cannot be accelerated indefinitely. During their motion, the electrons suffer elastic collisions with the metal ions which slow down their speed. This gives rise to a steady state current of magnitude proportional to the voltage applied provided the temperature remains constant.

~~Walter Rindler~~ _____

This leads to Ohm's law. Also ~~the~~ as the free electrons can move easily, the metals exhibit high electrical and thermal conductivities. Since the electrons move freely inside the metal irrespective of the crystal structure, the ratio of the electrical conductivity ' σ ' to the electrical conductivity ' κ ' should be constant, for all metals at a constant temp. i.e.

$$\frac{\sigma}{\kappa} = \text{Constant}$$

This is called the Wiedemann-Franz law

The theory also explains the high lustre and complete opacity of metals. The opacity is due to absorption of all the incident electromagnetic radiations by free electrons which are then set into forced oscillations. The electrons return to their normal states by emitting the same amount of energy in all directions thus producing metallic lustre.

