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CLASS 11&12th

CLASS 12th

Semiconductors

01. Distinction Between Metals, Insulators and Semi-Conductors

Metals are good conductors of electricity, insulators do not conduct electricity, while the semiconductors have conductivity in between those of metals and insulators.

*The energy band formed by a series of energy levels containing valence electrons is **valence band.***

*The highest energy level, which an electron can occupy in the valence band at 0 K, is called **Fermi level.***

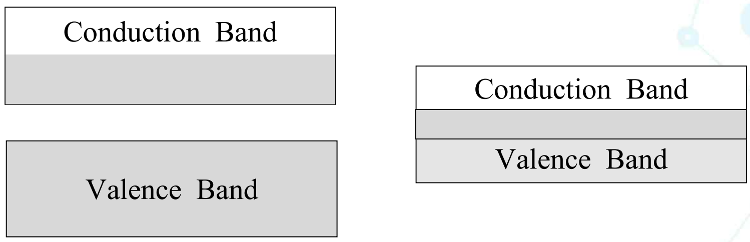
*The lowest unfilled energy band formed just above the valence band is called **conduction band.***

Depending upon the energy gap between valence band and the conduction band, the solids behave as conductors, insulators and semiconductors as explained below:

(a) **Metals**

The energy band structure in solids have two possibilities:

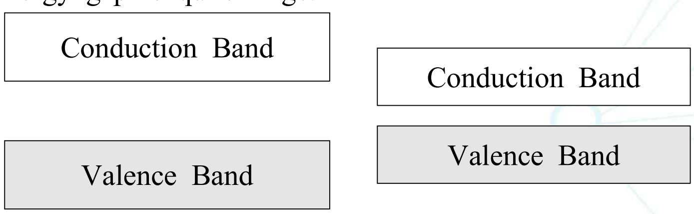
(i) *The valence band may be completely filled and the conduction band partially filled with an extremely small energy gap between them.*



(ii) *The valence band is completely filled and the conduction band is empty but the two overlap each other.*

(b) **Insulators**

The forbidden energy gap is quite large.



(c) **Semiconductors**

The energy band structure of the semiconductors is similar to the insulators but in their case; the size of the forbidden energy gap is much smaller than that for the insulators.

02. Increasing The Conductivity of a Semiconductor (Doping)

A pure semiconductor at room temperature possesses free electrons and holes but their number is so small that conductivity offered by the pure semiconductor cannot be made of any practical use.

By the addition of impurities to the pure semiconductor in a very small ratio ($1 : 10^6$), the conductivity of a Si-crystal (or Ge-crystal) can be remarkably improved.

The process of adding impurity to a pure semi conductor crystal (Si or Ge-crystal) so as to improve its conductivity, is called ***doping****.*

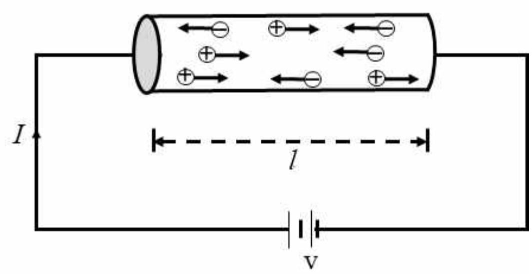
The impurity atoms are of two types:

(a) ***Pentavalent impurity atoms*** having 5 valence electrons such as antimony (Sb) or arsenic (As). Pentavalent impurity atoms are called ***donor impurity*** atoms. Semiconductor so produced is called ***n-type extrinsic semiconductor.***

(b) ***Trivalent impurity atoms*** having 3 valence electrons indium (In) or gallium (Ga). Trivalent impurity atoms are called ***acceptor impurity*** atoms. Semiconductor so produced is called ***p-type extrinsic semiconductor***.

03. Electrical Resistivity of Semiconductors

Consider a block of semiconductor of length l, area of cross-section A and having number density of electrons and holes as n_e and n_h respectively. Suppose that on applying a potential difference, say V, a current I flows through it as shown in figure.



The electron current (I_e) and the hole current (I_h) constitute the current I flowing through the semiconductor *i.e.*

$$I = I_e + I_h$$

If n_e is the number density of conduction band electrons in the semiconductor and v_e, the drift velocity of electrons, then electron current is given by

$$I_e = e\, n_e\, A\, v_e$$

Also, the hole current,

$$I_h = e\, n_h\, A\, v_h$$

or

$$I = e\, A\, (n_e\, v_e + n_h\, v_h)$$

If ρ is the resistivity of the material of the semiconductor, then the resistance offered by the semiconductor to the flow of current is given by

$$R = \rho \frac{l}{A}$$

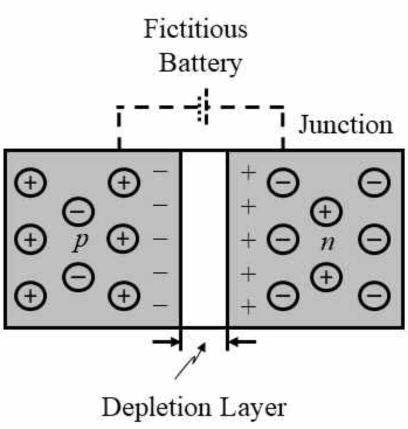
Therefore, $$\frac{1}{\rho} = e(n_e\mu_e + n_h\mu_h)$$

Also, $\sigma = \frac{1}{\rho}$ is called the conductivity of the material of semiconductor.

$$\sigma = e(n_e\mu_e + n_h\mu_h)$$

04. Formation of p-n Junction

A *p-n* junction is a basic semiconductor device. A *p*-type crystal placed in contact with n-type crystal to form one piece, the assembly is called ***p-n junction*** or ***junction diode*** or ***crystal diode***. In the *p*-section, holes are the majority carriers; while in *n*-section the majority carriers are electrons. Due to the high concentration of different types of charge carriers in the two sections, holes from *p*-region diffuse into *n*-region and electrons from *n*-region diffuse into *p*-region. When an electron meets a hole, the two cancel the effect of each other and as a result, a thin layer at the junction becomes devoid of charge carriers. This is called ***depletion layer*** as shown in.



The thickness of the depletion layer is of the order of 10^{-6} m.

05. Forward and Reverse Biasing on a Junction Diode

A junction diode can be biased in the following two ways:

(a) Forward Bias

When an external d.c. source is connected to the junction diode with p-section connected to positive pole and n-section to the negative pole, the junction diode is said to be forward biased.