# Mass Action Law:

This law is used to derive an important relationship between concentration of minority carriers and majority carriers at a constant temperature.

The addition of n-type impurities decreases the number of holes. Similarly, doping with p-type impurities decreases the concentration of free electrons.

A theoretical analysis lead to the result that under thermal equilibrium, the product of positive and negative charge carriers is a constant, irrespective of the amount of donor and acceptor impurities. This relationship is called the mass action law.

$$n_i^2=np \qquad \textbf{(equation 1)}$$

Where $n_i$ the intrinsic Carrier concentration is a function of temperature.

## Charge Densities in Semiconductors or Electron and Hole Concentration:

Charge carrier density, also known as carrier concentration, denotes the number of charge carriers in per volume. In SI units, it is measured in $m^{-3}$.

The mass action law (equation 1) is used to derive the carrier concentration in n-type or p-type material. The amount of majority carriers is approximately equal to the amount of impurity doping is added. The mass action law is used to find out the minority carrier concentration.

According to the principle of electrical neutrality, overall charge on any material should be equal.

$$N_D+p= N_A+n \qquad \text{(Equation 2)}$$

Where $N_D$= donor concentration

$N_A$=Acceptor concentration

p=hole concentration

n=electron concentration

**Intrinsic Semiconductors**

For intrinsic semiconductors $N_D=N_A=0$

From equation 2

$p=n$

By mass action law

$np=n_i^2$

$p^2=n^2=n_i^2$

$p=n=n_i$

**n-type Semiconductors**

For n-type Semiconductors $N_A=0$ and $N_D=n$

From the mass action law

$pn=n_i^2$

$p=n_i^2/n$

$$\mathbf{p=n_i^2/N_D} \qquad \textbf{equation 3}$$

The above equation is used to calculate the minority carriers concentration (in this case holes) in an n-type semiconductor.

**p-type Semiconductors:**

For p-type semiconductors $N_{D=}=0$ and $N_A=p$

From the mass action law

$np=n_i^2$

$n=n_i^2/p$

$$\mathbf{n=n_i^2/N_A} \qquad \textbf{equation 4}$$

The above equation is used to calculate the minority carrier's concentration (in this case electrons) in a p-type semiconductor.

This law is very important from the point of view that it enables us to determine minority carriers concentration. According to this law the addition of impurities to an intrinsic semiconductor increases the concentration of one type of carriers, which consequently become majority carriers and simultaneously decreases the concentration of the other carriers, which as a result become minority carriers.