Diode Current Equation :→

The relationship between applied voltage V and the diode current I is exponential and is mathematically given by the equation called diode current equation. It is expressed as,

$$I = I_o\left[e^{V/\eta V_T} - 1\right] \text{ A}$$

Where,

I_o = Reverse saturation current in A

V = Applied voltage

V_T = Volt equivalent of temperature in volts

η = 1 for Ge
= 2 for Si

The voltage equivalent of temperature (V_T) indicates dependence of diode current on temperature.

V_T for a given diode at temperature T is calculated as,

$$V_T = kT \text{ Volts}$$

or $$V_T = \frac{T}{11600}$$

where,

K = Boltzmann's Constant = 8.62×10^{-5} eV/°K

and T = Temperature in °K

Thus at room temperature of 27°C

i.e. $T = (27 + 273)^\circ K = 300^\circ K$

$$V_T = 8.62 \times 10^{-5} \times 300 = 0.02586\ V$$

$$\Rightarrow \boxed{V_T = 0.02586\ V \simeq 26\ mV}$$

Note:

The diode current equation is applicable for all the conditions of diode i.e. unbiased, forward biased and reverse biased.

Q. A Ge diode is used in a rectifier circuit and is operating at a temperature of 25°C with a reverse saturation current of 1000 μA. Calculate the value of forward current if it is forward biased by 0.22V.

Soln - Given -

$I_o = 1000\,\mu A = 1000 \times 10^{-6} A$

$V = 0.22\,V$

$T = 25°C = 25 + 273 = 298°K$

$\therefore V_T = KT = 8.62 \times 10^{-5} \times 298$

$= 0.025\,V$

and $\eta = 1$ for Ge

So, diode current equation,

$$I = I_o [e^{V/\eta V_T} - 1]$$

$$= 1000 \times 10^{-6} [e^{0.22/1 \times 0.025} - 1]$$

$$= 1000 \times 10^{-6} \times 6633.24$$

$$= 6.6332\,A$$

Q. A Ge diode has a reverse saturation current of 3 μA. Calculate the voltage at which 1% of the rated current will flow through the diode, at room temperature if diode is rated for 1 A.

Soln- Here,

$\eta = 1$ for Ge

$I_o = 3\,\mu A = 3 \times 10^{-6}\ A$

Rated current is 1A, and

$I = 1\%$ of rated current $= 0.01\ A$

$V_T = 0.2586\ V$ at room temperature

Using diode current equation:

$$I = I_o [e^{V/\eta V_T} - 1]$$

i.e. $0.01 = 3 \times 10^{-6} [e^{V/1 \times 0.02586} - 1]$

$$\Rightarrow e^{V/0.02586} - 1 = \frac{.01}{3 \times 10^{-6}} = \frac{10^4}{3}$$

$$\Rightarrow e^{V/0.02586} - 1 = 3333.33$$

$$\Rightarrow e^{V/.02586} = 3334.34$$

$$\Rightarrow \frac{V}{0.02586} = \ln 3334.34 = 8.112$$

$$\Rightarrow V = 0.2097\ V \quad \text{Ans.}$$