Numerical on "Characteristic/Current Equation of PN junction Diode ".

Ex1. Calculate the forward bias current of a Si diode (η = 1) when forward bias voltage of 0.4V is applied, the reverse saturation current is 1.17×10^{-9}A and the thermal voltage is 25.2mV.

Solution: Equation for diode current
$I=I_0\times(e^{(V/\eta V_T)}-1)$ where I_0 = reverse saturation current
η = ideality factor
V_T = thermal voltage
V = applied voltage
Since in this question ideality factor is not mentioned it can be taken as one.
$I_0 = 1.17 \text{ x } 10^{-9}$A, $V_T = 0.0252$V, $\eta = 1$, V = 0.4V
Therefore, $I= 1.17\times10^{-9} x e^{0.4/0.025} -1 = 9.156$mA.

Ex 2. Calculate the thermal voltage when the temperature is 25°C.

Solution: Thermal voltage V_T is given by k T/q
Where k is the boltzman constant and q is the charge of electron. This can be reduced to
$V_T = T_K/11600$
Therefore, $V_T = 298.15/11600 = 0.0257$V.

Ex 3. Calculate the reverse saturation current of a diode if the current at 0.2V forward bias is 0.1mA at a temperature of 25°C and the ideality factor is 1.5.

Solution: Equation for diode current
$I=I_0\times(e^{(V/\eta V_T)}-1)$ where I_0 = reverse saturation current
η = ideality factor
V_T = thermal voltage
V = applied voltage
Here, I = 0.1mA, η = 1.5, V= 0.2V, $V_T = T_K/11600$
Therefore, V_T at T= 25+273=298 is 298/11600 = 0.0256V.

Therefore, reverse saturation current $I_0 = 0.1 \times \frac{10^{-3}}{e^{\frac{0.2}{1.5x0.0256}}-1}$
I_O=0.00055mA = 5.5×10^{-7}A.

Ex 4. Find the applied voltage on a forward biased diode if the current is 1mA and reverse saturation current is 10^{-10}. Temperature is 25°C and take ideality factor as 1.5.

Solution: Equation for diode current
$I=I_0\times(e^{(V/\eta V_T)}-1)$ where I_0 = reverse saturation current

η = ideality factor
V_T = thermal voltage
V = applied voltage
V_T at T= 25+273=298 is 298/11600 = 0.0256V, η = 1.5, I = 1mA, $I_0 = 10^{-10}$A

$$V = \eta V_T \ln\left(\left(\frac{I}{I_0}\right) + 1\right) = 1.5x0.0256x\ln\left(\frac{10^{-3}}{10^{-10}} + 1\right) = 0.618V$$

Ex 5. Find the temperature at which a diode current is 2mA for a diode which has reverse saturation current of 10^{-9} A. The ideality factor is 1.4 and the applied voltage is 0.6V forward bias.

Solution: Equation for diode current
$I=I_0\times(e^{(V/\eta V_T)}-1)$ where I_0 = reverse saturation current
η = ideality factor
V_T = thermal voltage
V = applied voltage
I_0 = 10-9A, η = 1.4, V =0.6V, I = 2mA

$$\text{Thermal voltage } V_T = \frac{V}{\eta\ln\left(\frac{I}{I_0}+1\right)} = \frac{0.6}{1.4\times\ln\left(2\times\frac{10^{-3}}{10^{-9}}+1\right)} = 0.0295V$$

We know thermal voltage $V_T = T_K/11600$ .Therefore, $T_K = V_T x11600$ = 0x11600 = 342.65K = 69.65°C.

Ex 6. Consider a silicon diode with η=1.2. Find change in voltage if the current changes from 0.1mA to 10mA.

Solution: Equation for diode current
$I=I_0\times(e^{(V/\eta V_T)}-1)$ where I_0 = reverse saturation current
η = ideality factor
V_T = thermal voltage
V = applied voltage
η = 1.2, I2 = 10mA, I1 = 0.1mA and take V_T = 0.026V

$$\text{Change in voltage } \Delta V = \eta V_T \ln\left(\frac{I_2}{I_1}\right) = 1.2x0.026x\ln\left(10\times\frac{10^{-3}}{0.1\times10^{-3}}\right) = 0.143V$$

Ex 7. If current of a diode changes from 1mA to 10mA what will be the change in voltage across the diode. The ideality factor of diode is 1.2.

Solution: η = 1.2, I2 = 10mA, I1 = 1mA and take V_T = 0.026V

$$\text{Change in voltage } \Delta V = \eta V_T \ln\left(\frac{I_2}{I_1}\right) = 1.2x0.026x\ln\left(10\times\frac{10^{-3}}{1\times10^{-3}}\right) = 0.0718V.$$

Ex 8. What will be the ratio of final current to initial current of a diode if voltage of a diode changes from 0.7V to 872.5mV. Take ideality factor as 1.5.

Solution: $\eta = 1.5$, $\Delta V = 0.8725V$ and take $V_T = 0.026V$

Change in voltage $\Delta V = \eta V_T \ln\left(\frac{I_2}{I_1}\right)$

Therefore, $\frac{I_2}{I_1} = e^{\frac{\Delta V}{\eta V_T}} = e^{\frac{0.8725}{1.5 \times 0.026}} = 83.35$