Q. Consider an n-channel MOSFET with $W = 15\mu m$, $L = 2\mu m$ & $C_{ox}' = 6.9\times10^{-8}\ F/cm^2$. Assume that the drain current in the Non Saturation region for $V_{DS} = 0.1V$ is $I_D = 35\mu A$ at $V_{GS} = 1.5V$ and $I_D = 75\mu A$ at $V_{GS} = 2.5V$. Then Inversion Carrier Mobility is ____ $cm^2/V\text{-}sec$.

2M

Sol:- Since, $I_D = \mu_n C_{ox}' \frac{W}{L}[V_{GS} - V_{Th}]V_{DS}$ [$\because$ Deep Triode, $V_{DS} \rightarrow$ very small]

$$\Rightarrow I_{D_2} - I_{D_1} = \frac{W}{L}\mu_n C_{ox}'[V_{GS_2} - V_{GS_1}]$$

$$\Rightarrow 75\times10^{-6} - 35\times10^{-6} = \frac{15}{2}\mu_n(6.9\times10^{-8})(2.5-1.5)(0.10)$$

By solving $\mu_n = 773\ cm^2/v\text{-}sec.$

(20). (1M) From a Semiconductor Device, If $\sigma_p = 1\ \mho/cm$, $\sigma_n = 0.1\ \mho/cm$, $L_n = L_p = 0.15\ cm$, then Find the Ratio of hole Diffusion Current to Electron Diffusion Current Crossing the Junction in a pn Diode is: ______ ?

a). 10. b). 20.

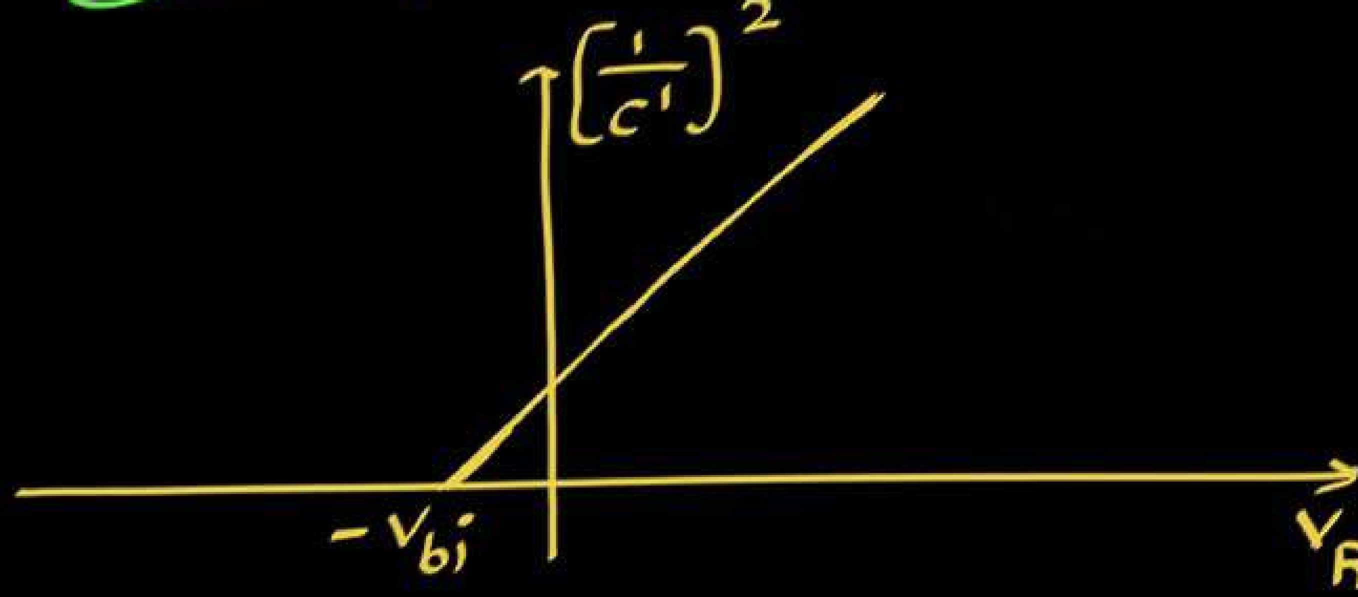
c). 100 d). 0.1

Sol:- Since $\dfrac{I_{p_n}(x)}{I_{np}(x)} = \dfrac{L_n}{L_p} \cdot \dfrac{\sigma_p}{\sigma_n} = \dfrac{\sigma_p}{\sigma_n}$ [$\because$ Given $L_p = L_n$].

$$= \frac{1}{0.1} = 10.$$

$\therefore$ Option-a is Correct.

Q. Determine the Impurity doping Concentrations in a p^+n Junction shown in figure. Assume $V_{bi} = 0.725V$, & Slope is $6.15 \times 10^{15} \left(\frac{F}{cm^2}\right)^{-2} V^{-1}$ respectively, where Operating Temperature $T = 300^\circ K$.



a). $1.6 \times 10^{17}/cm^3$

b). $1.8 \times 10^{25}/cm^3$

c). $1.9 \times 10^{24}/cm^3$

d). $1.96 \times 10^{15}/cm^3$

2M

Sol:- Since we know → p^+n → One sided

↓

$$\Rightarrow W \cong \left[\frac{2\epsilon}{q} \cdot \frac{1}{N_D} \cdot (V_{bi} + V_D)\right]^{1/2}$$

where V_D → under R. Bias.

Need to find both N_A & N_D

As $$C_j' = \left(\frac{q\,\epsilon_{si}\,N_D}{2(V_{bi} + V_D)}\right)^{1/2} \Rightarrow \left(\frac{1}{C_j'}\right)^2 = \frac{2(V_{bi} + V_D)}{q\,N_D\,\epsilon_{si}}.$$

$$\therefore \text{Slope} = \frac{2}{q\,\epsilon_{si}\,N_D}.$$

$$\Rightarrow N_D = \frac{2}{q\,\epsilon_{si}} \cdot \frac{1}{\text{slope}} = \frac{2}{1.6\times10^{-19} \times 11.7 \times 8.85\times10^{-14} \times 6.15\times10^{15}}.$$

$$\Rightarrow \boxed{N_D = 1.96\times10^{15}/cm^3.}$$

As $V_{bi} = \frac{KT}{q}\log_e\left|\frac{N_D N_A}{n_i^2}\right|$

$$\Rightarrow N_A = \frac{n_i^2}{N_D}\exp\left(\frac{V_{bi}}{V_T}\right)$$

$$= \frac{(1.5\times10^{10})^2}{1.963\times10^{15}}\exp\left(\frac{0.725}{0.0259}\right)$$

$$\Rightarrow N_A = 1.64\times10^{17}/cm^3 \longrightarrow$$

option-(a) & option-(d).

Q. Under n-channel Si MOSFET at $T = 300°K$, Assume the Substrate is Doped to $N_A = 3 \times 10^{16}/cm^3$ & $t_{ox} = 20nm$, with $V_{SB} = 1V$. Then Find Change in Threshold Voltage?

Sol:- There Exist Body Effect.

(2M)

As $V_{Th} = V_{Th_0} + \gamma\left[\sqrt{2\phi_{fp} + |V_{SB}|} - \sqrt{2\phi_{fp}}\right]$

$\Rightarrow \Delta V_{Th} = V_{Th} - V_{Th_0} = \gamma\left[\sqrt{2\phi_{fp} + |V_{SB}|} - \sqrt{2\phi_{fp}}\right]$.

Since, $\gamma = \dfrac{\sqrt{2q\epsilon_{si}N_A}}{C_{ox}'}$, where $\phi_{fp} = \dfrac{kT}{q}\log_e\left|\dfrac{N_A}{n_i}\right| = 0.3758V$.

$C_{ox}' = \dfrac{\epsilon_0 (\epsilon_r)_{SiO_2}}{t_{ox}} = 1.726 \times 10^{-7} F/cm^2$.

Now we get $\gamma = \dfrac{\left[2(1.6\times10^{-19})(11.7)(8.85\times10^{-14})(3\times10^{16})\right]^{1/2}}{1.726\times10^{-7}}$.

$$\Rightarrow \gamma = 0.5776\sqrt{V}.$$

$$\therefore \Delta V_{Th} = (0.5776)\left[\sqrt{2(0.3758)+1} - \sqrt{2(0.3758)}\right]$$

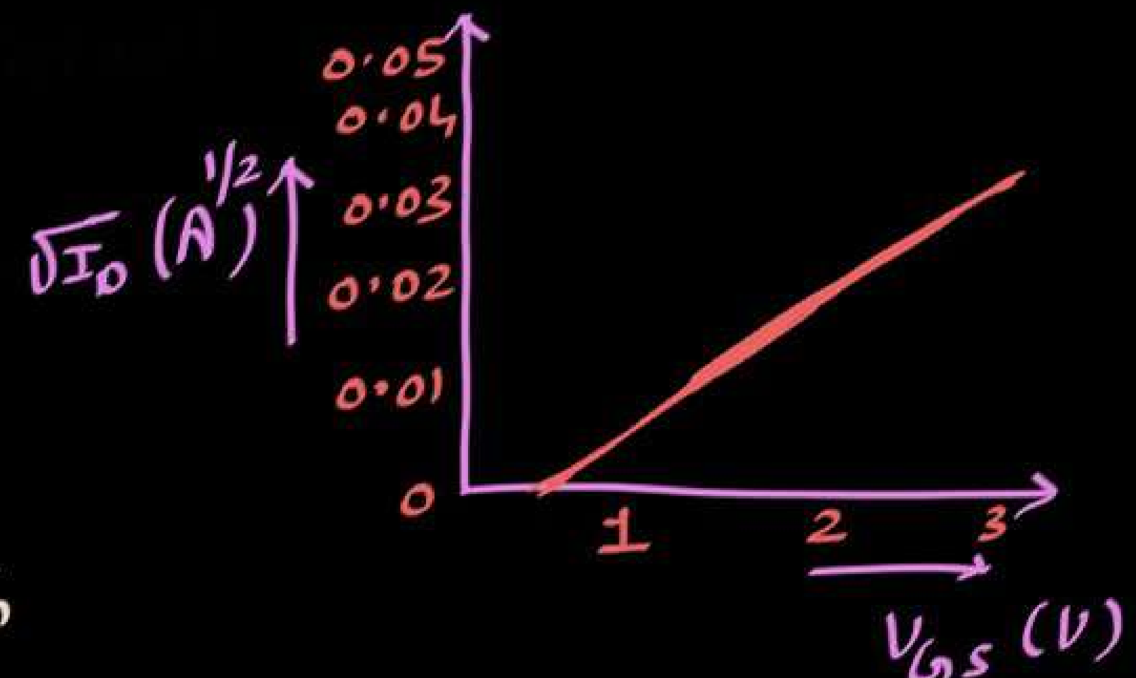
$$\therefore \Delta V_{Th} = 0.264V.$$

Q: One Curve of an n-channel MOSFET is characterized by the following parameters: $I_{D_{sat}} = 2\times10^{-4}A$, $(V_{DS})_{sat} = 4V$ & $V_{Th} = 0.8V$.

Then what is the value of Conduction parameter

______ $(\mu A/V^2)$?

(2M)



Sol:- Since $(V_{DS})_{sat} = V_{GS} - V_{Th}$

$\Rightarrow 4 = V_{GS} - 0.8 \Rightarrow V_{GS} = 4.8V.$

$\Rightarrow (I_D)_{sat} = k_n (V_{GS} - V_{Th})^2 = k_n (V_{DS})^2_{sat} \Rightarrow 2\times10^{-4} = k_n(16).$

$\Rightarrow k_n = 12.5\,\mu A/V^2.$

Q. Consider an n-type silicon photoconductor with length $L = 100\mu m$, cross sectional area, $A = 10^{-7} cm^2$, minority life time $\tau_p = 10^{-6}$ sec, with applied voltage, $V = 10V$. Calculate photo conductor gain?

1ST

a). 1.83×10^2. b). 1.9×10^4. c). 1.83×10^{12}. d). 1.9×10^3.

Sol:- Since photo conductor gain $= \frac{\tau_p}{t_n}\left[1 + \frac{\mu_p}{\mu_n}\right]$,

where Electron Transit time, $t_n = \frac{L}{\mu_n E} = \frac{L^2}{\mu_n V} = \frac{(100 \times 10^{-4})^2}{1350 \times 10}$

$= 7.41 \times 10^{-9}$ sec.

$\therefore$ Gain $= \frac{10^{-6}}{7.41 \times 10^{-9}}\left[1 + \frac{480}{1350}\right] = 1.83 \times 10^2$.

$\Rightarrow$ Option-(a).

Q. A long si pn solar cell @ $T = 300°K$, with $N_A = 10^{16}/cm^3$, $N_D = 10^{15}/cm^3$, $D_n = 25\,cm^2/sec$, $D_p = 10\,cm^2/sec$, $\tau_{n_0} = 10^{-6}\,sec$ & $\tau_{p_0} = 5\times10^{-7}\,sec$. The Cross Sectional Area of Solar cell is $5\,cm^2$. The generated photo current, $I_L = 120\,mA$. Determine Maximum power output of the Solar cell. [Consider leakage current, $I_S = 8.95\times10^{-10}\,A$].
(order of mW)

2M

Sol:- Since, $\left[1 + \frac{V_m}{V_T}\right] \exp\left(\frac{V_m}{V_T}\right) = 1 + \frac{I_L}{I_s}$

where $I_s = 8.95\times10^{-10}$ Amp., $\Rightarrow$ we get $V_m \cong 0.412V$.

Also, $I_m = I_L - I_s\left[\exp\left(\frac{V_m}{V_T}\right) - 1\right] \Rightarrow I_m = 112.75\,mA$.

$\therefore P_m = V_m I_m = 46.5\,mW$.