EE 210

Soln. to HA # 1

1 i) a) $V_D = 50\,mV \Rightarrow$ comparable to $V_T \Rightarrow I_D = I_0\,(e^{V_D/V_T} - 1)$

$= 10\,pA \times (e^{50/26} - 1) = \underline{58.42\,pA}$ (from $\underline{p \text{ to } n}$)

b) $V_D = 500\,mV \Rightarrow \gg V_T \Rightarrow I_D \simeq I_0 e^{V_D/V_T} = 10\,pA \times e^{500/26} = \underline{2.25\,mA}$ ($\underline{p \text{ to } n}$)

ii) a) $V_D = -50\,mV \Rightarrow I_D = 10\,pA \times (e^{-50/26} - 1) = \underline{-8.54\,pA}$

(−ve sign implies that the current is flowing from $\underline{n \text{ to } p}$)

b) $V_D = -500\,mV \Rightarrow I_D \simeq -I_0 = \underline{-10\,pA}$ ($\underline{n \text{ to } p}$)

———— × ————

2 ∵ D_2 is rev. biased, major part of V_{AP} will drop across it, & $I_D \simeq I_0(D_2) = \underline{1\,nA}$. The same current also flows thru D_1.

$\Rightarrow I_D = I_0(D_1)\left(e^{V_{D1}/V_T} - 1\right) \Rightarrow V_{D1} = V_T \ln\left(\frac{I_D}{I_0(D_1)} + 1\right)$

∵ $I_D\,(= 1\,nA)$ is 10^3 times $I_0(D_1)\,(= 1\,pA)$

$\Rightarrow V_{D_1} \simeq V_T \ln \frac{I_D}{I_0(D_1)} = 26\,mV \times \ln \frac{1\,nA}{1\,pA} = \underline{179.6\,mV}$

& $V_{D_2} = V_{AP} - V_{D_1} = 5\,V - 179.6\,mV = \underline{4.82\,V}$

———— × ————

3 2 defining relns ⇒ $I_D = \frac{10 - V_D}{1K}$ & $I_D = 10\,pA \times e^{V_D/26\,mV}$

Rearrange $V_D = 26\,mV \times \ln \frac{I_D}{10\,pA}$ choose $V_D = 0.7\,V$ as initial guess, ∵ this set of eqns. can be solved only thru iterations.

Gives $I_D = \underline{9.3\,mA} \Rightarrow V_D = \underline{0.537\,V} \Rightarrow I_D = \underline{9.463\,mA} \Rightarrow V_D = \underline{0.537\,V}$

⇒ Convergence in just 2 iterations.

$\Rightarrow \boxed{V_D = 0.537\,V}$ & $\boxed{I_D = 9.463\,mA}$

———— × ————

4. Abrupt jn. $\Rightarrow m = 1/2 \quad C_{dep} = \dfrac{C_{dep0}}{\left(1 - \frac{V_D}{V_0}\right)^{1/2}}$

$\Rightarrow \dfrac{1}{C_{dep}^2} = \dfrac{1}{C_{dep0}^2 V_0}(V_0 - V_D)$ Compare with the given expression

$\dfrac{1}{C_{dep}^2} = 1.5625 \times 10^6 (0.64 - V_D) \Rightarrow \boxed{V_0 = 0.64V}$

Also, $C_{dep0}^2 V_0 = 6.4 \times 10^{-7}$ which gives $C_{dep0} = 10^{-3}\,\mu F = \boxed{1nF}$

And $C_{dep0} = \dfrac{\epsilon_S A}{W} \Rightarrow W = \dfrac{\epsilon_S A}{C_{dep0}} = \dfrac{11.7 \times 8.854 \times 10^{-14} \times 10 \times 10^{-2}}{10^{-9}} \simeq \boxed{1\mu m}$

---

5. $I_{DQ} = 9.463mA \Rightarrow r_D = \dfrac{V_T}{I_{DQ}} = \dfrac{26mV}{9.463mA} = \underline{\underline{2.75\Omega}}$

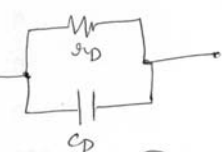
Jn. is linearly graded $\Rightarrow C_{dep} = \dfrac{C_{dep0}}{\left(1 - \frac{V_D}{V_0}\right)^{1/3}} = \dfrac{1pF}{\left(1 - \frac{0.537}{0.8}\right)^{1/3}} = \underline{\underline{1.45pF}}$

$C_{diff} = g_m \tau = \dfrac{\tau}{r_D} = \dfrac{1\mu s}{2.75\Omega} = \underline{\underline{0.364\mu F}}$

* Note that in general for a forward biased diode, $C_{diff} \gg C_{dep}$.

$\Rightarrow C_D = C_{diff} + C_{dep} \simeq C_{diff} = \underline{\underline{0.364\mu F}}$

Small-Signal Model:



$\boxed{\begin{array}{l} r_D = 2.75\Omega \\ C_D = 0.364\mu F \end{array}}$

Diode time constant $\tau_D = r_D C_D = \boxed{1\mu s}$
