Paggy Wu
202912053
EE 113A
Dis 1E

Ch 3 / 16, 22, 26, 32, 38

16. V = +3V

D_1 = ON → red lamp ON

D_2 = OFF → green lamp off

V = 0 V

D_1 = OFF

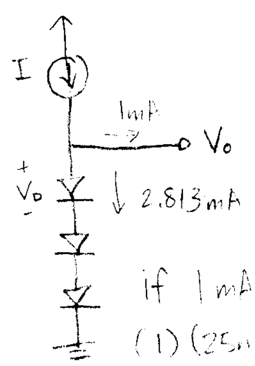
D_2 = OFF

V = −3V

D_1 = OFF → red lamp off

D_2 = ON → green lamp ON

22.



$n = 1$

$I_S = 10^{-14} A$

$V_o = 2\ V = 3V_D$

$V_D = \frac{2}{3} V$

$V_T = 25mV$

$$I = I_S e^{\frac{V_D}{nV_T}} = (10^{-14}) e^{\frac{\frac{2}{3}V}{25mV}} = 3.812\ mA$$

$\boxed{I = 3.812mA}$

if 1mA drawn away → $V_{D_{new}} - V_{D_{old}} = nV_T \ln \frac{I_{new}}{I_S} - nV_T \ln \frac{I_{old}}{I_S}$

$(1)(25mV) \ln \frac{2.8mA}{10^{-14}A} - (1)(25mV) \ln \frac{3.8mA}{10^{-14}A} = -7.63mV \ast 3 = \boxed{22.9mV}$ = Total change in V_o

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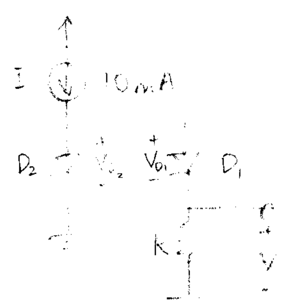

10mA @ 0.7V V = 50mV 100mA @ 0.8V

$I_D = I_S e^{\frac{V_D}{nV_T}}$

$I_1 = I_S e^{\frac{V_{D_1}}{nV_T}}$

$I_1 + I_2 = 10mA$

$V_{D_2} = V_{D_1} + 50mV$

$I_2 = I_S e^{\frac{V_{D_2}}{nV_T}} = I_S e^{\frac{V_{D_1} + 50mV}{nV_T}} = I_S e^{\frac{V_{D_1}}{nV_T}} e^{\frac{50mV}{nV_T}} = I_1 e^{\frac{50mV}{nV_T}}$

$I_1 + I_2 = 10mA$ @ 0.7V

$I_1 + I_1 e^{\frac{50mV}{nV_T}} = 10mA$

$I_1(1 + e^{\frac{50mV}{nV_T}}) = 10mA$ → $I_1 = \frac{10mA}{1 + e^{\frac{50mV}{nV_T}}}$

$10mA = I_S e^{\frac{0.7V}{nV_T}}$

$I_S = \frac{10mA}{e^{\frac{0.7}{nV_T}}}$

$I_S = \frac{10mA}{e^{\frac{0.7}{(1.737)(0.025)}}}$

$I_S = 10^{-9} A$

$100mA = I_S e^{\frac{0.8V}{nV_T}}$

$100mA = \frac{10mA}{e^{\frac{0.7}{nV_T}}} \cdot e^{\frac{0.8}{nV_T}}$

$10 = e^{\frac{0.1}{n(25mV)}}$

$\ln 10 = \frac{0.1}{n(25mV)}$

$n = \frac{0.1}{\ln 10 (25mV)} = 1.737$

$I_1 = \frac{10mA}{1 + e^{\frac{50mV}{1.737(25mV)}}} = 2.4mA$

$R = \frac{V}{I_1} = \frac{50mV}{2.4mA}$

$\boxed{R = 20.8}$

32. $N_D = 10^{16}/cm^3$ $\quad q = 1.6\times10^{-19}$
$n_i = 1.5\times10^{10}/cm^3$ $\quad D_p = 12\ cm^2/s$
$W = 5\mu m$
Find density of current that will flow in x direction

$p_{no} = \frac{n_i^2}{N_D} = \frac{(1.5\times10^{10}/cm^3)^2}{10^{16}/cm^3} = 2.25\times10^4/cm^3$

$\frac{dp}{dx} = \frac{p_{no} - 1000p_{no}}{w} = \frac{-999(2.25\times10^4)/cm^3}{5\times10^{-4}cm}$

$= -4.495\times10^{10}/cm^2$

$I_p = -q D_p \frac{dp}{dx} = -(1.6\times10^{-19})(12\ cm^2/s)(-4.495\times10^{10}/cm^2)$

$\boxed{I_p = 8.64\times10^{-8}/cm^2}$

38 $N_D = N_A = 10^{16}$ atoms$/cm^3$ $\quad A = 100\ \mu m^2$
$n_i = 10^{10}/cm^3$
Find built in Voltage V_B, width of depletion region W,
How far it extends to p & n regions x_p, x_n &
magnitude of charge stored and calculate C_j

$V_B = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right) = (0.025)\ln\left(\frac{10^{16}\times10^{16}}{10^{20}}\right) = 0.691V$ $\quad \boxed{V_B = 0.691V}$

$W = \sqrt{\frac{2\varepsilon}{q}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)V_B} = \sqrt{\frac{2(11.7)(8.85\times10^{-14})}{1.6\times10^{-19}}\left(\frac{1}{10^{16}}+\frac{1}{10^{16}}\right)0.691} = 4.23\times10^{-5}cm$

$W = 4.23\times10^{-7}m$ $\quad \boxed{W = 0.423\mu m}$

$x_p = x_n = \frac{0.423\mu m}{2} = 2.115\times10^{-7}$ $\quad \boxed{x_p = x_n = 0.21\mu m}$

$N_D = 10^{16}/cm^3 = 10^4/\mu m^3$

$\frac{10^{16}}{(10^{-2}m)^3} = \frac{X}{(10^{-6}m)^3} \Rightarrow X = 10^4$

$q_j = q_n = q_p = q\left(\frac{N_A N_D}{N_A+N_D}\right)A\,W_{dep} = (1.6\times10^{-19})\left(\frac{10^4\times10^4}{10^4+10^4}\right)(100)(0.42)$

$\boxed{q_n = q_p = 3.36\times10^{-14}C}$

$C_j = \frac{\varepsilon_s A}{W} = \frac{(11.7)(8.85\times10^{-14}F/cm)(100\mu m)}{0.42} = 2.47\times10^{-14}F$ $\quad \boxed{C_j = 2.47\times10^{-14}F}$