$\boxed{1}$ $V = IR \Rightarrow R = \rho \frac{L}{A}$

$$R = \frac{L}{\sigma A}$$

For n-type $\sigma = e \mu_n N_d$
because for complete Ionization $n \simeq N_d$

$N_d = 5 \times 10^{16}\ cm^{-3}$
From the graph $\mu_n \simeq 1100\ cm^2/V.s$

$$R = \frac{0.1}{\underbrace{(1.6 \times 10^{-19})}_{e=q}(1100)(5 \times 10^{16})(100 \times \underbrace{10^{-4}}\times \underbrace{10^{-4}})}$$

Conversion from μm to cm

$R = 1.136 \times 10^4\ \Omega$

a) $I = \frac{V}{R} = 0.44\ mA$

b) if the lenght reduced to $0.01\ cm \Rightarrow R = 1.136 \times 10^3$

$$I = \frac{V}{R} = \frac{5}{1.136 \times 10^3} = 4.4\ mA$$

c) $v_d = \mu_n E \quad , \quad E = \frac{V}{L}$

for a) $v_d = 1100\left(\frac{5}{0.1}\right) = 5.5\times10^{4}$ cm/s

for b) $v_d = 1100\,(500) = 5.5\times10^{5}$ cm/s

$\boxed{2}$ $\sigma_i = e\, n_i\, (\mu_n + \mu_p)$

a) For $N_d = N_a = 10^{16}\ cm^{-3}$, $\mu_n = 1350\ cm^2/V.s$

$\mu_p = 480\ cm^2/V.s$ {μ_n, μ_p from the graphs}

$\sigma_i = (1.6\times10^{-19})(1.5\times10^{10})(1350+480)$

$\sigma_i = 4.39\times10^{-6}\ (\Omega cm)^{-1}$

b) For $N_d = N_a = 10^{18}\ cm^{-3}$, $\mu_n = 300\ cm^2/V.s$

$\mu_p = 130\ cm^2/V.s$

$\sigma_i = (1.6\times10^{-19})(1.5\times10^{10})(300+130) =$

$\sigma_i = 1.03\times10^{-6}\ (\Omega cm)^{-1}$

$\boxed{3}$ a) $v_d = \mu_n E = 1350 \times 10 = 1.35 \times 10^{4}$ cm/s

$K.E. = \frac{1}{2} m_n^* v_d^2 = \frac{1}{2}(1.08 \times 9.11 \times 10^{-31})(1.35 \times 10^{2})^2$

$= 8.97 \times 10^{-27}$ J

$= 5.6 \times 10^{-8}$ eV

b) $K.E. = \frac{1}{2}(1.08 \times 9.11 \times 10^{-31})(1.35 \times 10^{4})^2$

$= 8.97 \times 10^{-23}$ J $= 5.6 \times 10^{-4}$ eV

$\boxed{4}$ $\mu_n \propto T^{-\frac{3}{2}}$

$\mu_n = 1300 \left(\frac{T}{300}\right)^{-3/2}$

a) at $T = 200$ K, $\mu_n = 1300 \times 1.837$

$\mu_n = 2388$ cm^2/V.s

b) at $T = 400$ K, $\mu_n = 1300 \times 0.65$

$\mu_n = 844$ cm^2/V.s

$\boxed{5}$ $J = e D_n \frac{dn}{dx} = e D_n \frac{\Delta n}{\Delta x}$

$= (1.6\times10^{-19})(25)\left(\frac{10^{16}-10^{15}}{0-0.01}\right)$

$|J| = 0.36\ A/cm^2$

$I = JA = 0.36 \times 0.05 = 18\ mA$

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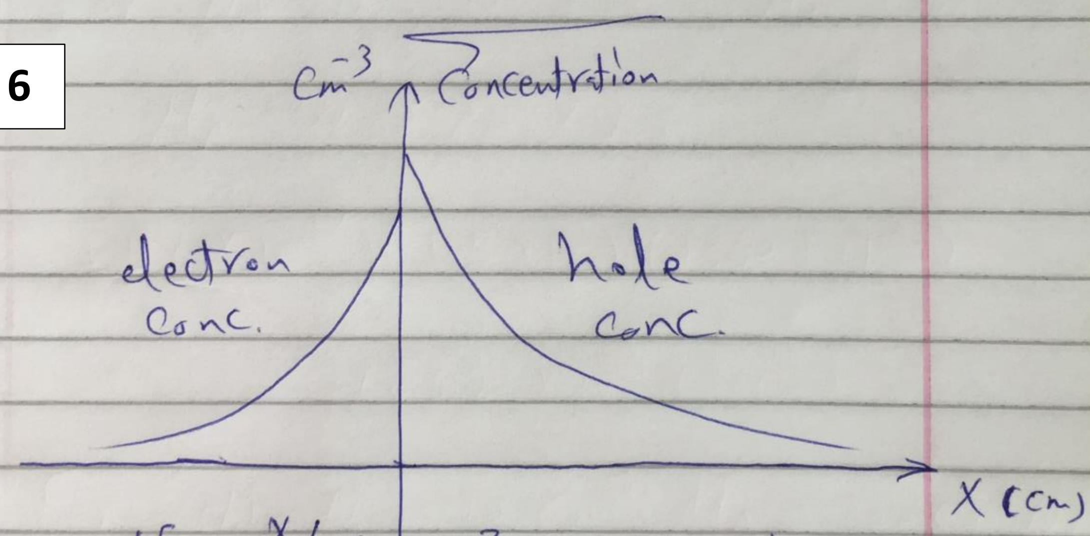

$p = 10^{15} e^{-x/L_p}\ cm^{-3},\ L_p = 5\times10^{-4}\ cm,\ D_p = 10\ cm^2/s$

$n = 5\times10^{14} e^{x/L_n}\ cm^{-3},\ L_n = 10^{-3}\ cm,\ D_n = 25\ cm^2/s$

$$J_p(x=0) = -e D_p \left.\frac{dp}{dx}\right|_{x=0}$$

$$= -e D_p (10^{15})\left(\frac{-1}{L_p}\right) \left. e^{-x/L_p}\right|_{x=0}$$

$$= \frac{-1.6\times10^{-19} \times 10 \times 10^{15} \times -1}{5\times10^{-4}} \times e^{0}$$

$$= 3.2 \ A/cm^2$$

$$J_n(x=0) = e D_n \left.\frac{dn}{dx}\right|_{x=0}$$

$$= e D_n (5\times10^{14})\left(\frac{1}{L_n}\right) \left. e^{x/L_n}\right|_{x=0}$$

$$= \frac{1.6\times10^{-19} (5\times10^{14})(25)}{10^{-3}} = 2 \ A/cm^2$$

$$J = J_p(x=0) + J_n(x=0)$$

$$= 3.2 + 2 = 5.2 \ A/cm^2$$

$\boxed{7}$ $n(x) = 10^{16} e^{-x/18}\ cm^{-3}$, $D_n = 25\ cm^2/s$

$\mu_n = 960\ cm^2/V.s$, $J_n = -40$

$$J_n = J_{n,drift} + J_{n,diff}$$

$$= e\mu_n n E + e D_n \frac{dn}{dx}$$

$$-40 = (1.6\times10^{-19})(960)\times(10^{16} e^{-x/18}) E$$

$$+ (1.6\times10^{-19})(25)(10^{16}\times(\frac{-1}{18\times10^{-4}}) e^{-x/18}$$

$$-40 = 1.536 e^{-x/18} E - 22.2 e^{-x/18}$$

$$E = \frac{-40 + 22.2 e^{-x/18}}{1.536 e^{-x/18}} = 14.5 - 26 e^{x/18}$$

$$\boxed{E = 14.5 - 26 e^{x/18}}$$

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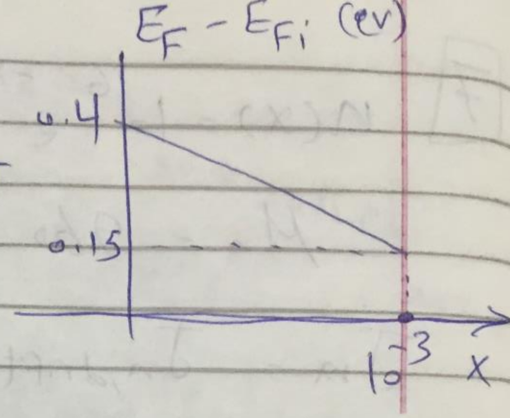

a) $n = n_i \, e^{(E_F - E_{Fi})/KT}$

$E_F - E_{Fi} = mx + c$

$= \left[\frac{0.4 - 0.15}{0 - 10^{-3}}\right] x + (0.4)$

$= 0.4 - 250x$

$n = n_i \, e^{(0.4 - 250x)/KT}$

b) $J_n = e D_n \frac{dn}{dx} = e D_n n_i \left(\frac{250}{KT}\right) e^{\frac{0.4 - 250x}{KT}}$

For $T = 300\,K \Rightarrow KT = 0.0259$

$, n_i = 1.5 \times 10^{10}\ cm^{-3}$

$J_n = -5.79 \times 10^{-4} \, e^{(0.4 - 250x)/0.0259}$

(i) at $x = 0 \Rightarrow J_n = -2.95 \times 10^{3}\ A/cm^2$

(ii) at $x = 5\,\mu m \Rightarrow J_n = -23.7\ A/cm^2$

$\boxed{9}$ a) $N_d(x) = N_{do}\, e^{-x/L}$, $L = 0.1\ \mu m$

$$J_{n,drift} = e D_n \frac{dn}{dx} = e D_n \frac{dN_d(x)}{dx}$$

$$= \frac{e D_n}{-L} N_{do}\, e^{-x/L}$$

$$\frac{D_n}{\mu_n} = \frac{KT}{e} \Rightarrow D_n = 155.4\ cm^2/s$$

$$J_{diff} = \frac{-(1.6\times10^{-19})(155.4)(5\times10^{16})}{(0.1\times10^{-4})} e^{-x/L}$$

$$= -1.24\times10^{5}\, e^{-x/L}\ A/cm^2$$

b) $J_{diff} + J_{drift} = 0$ [Compensation Cond]

$$J_{drift} = e\mu_n n E = (1.6\times10^{-19})(6000)(5\times10^{16})\, e^{-x/L} E$$

$$= 48\, e^{-x/L}$$

$$J_{drift} = -J_{diff}$$

$$48\, e^{-x/L} = 1.24\times10^{5}\, e^{-x/L}$$

$$\therefore E = 2.58\times10^{3}\ V/cm$$