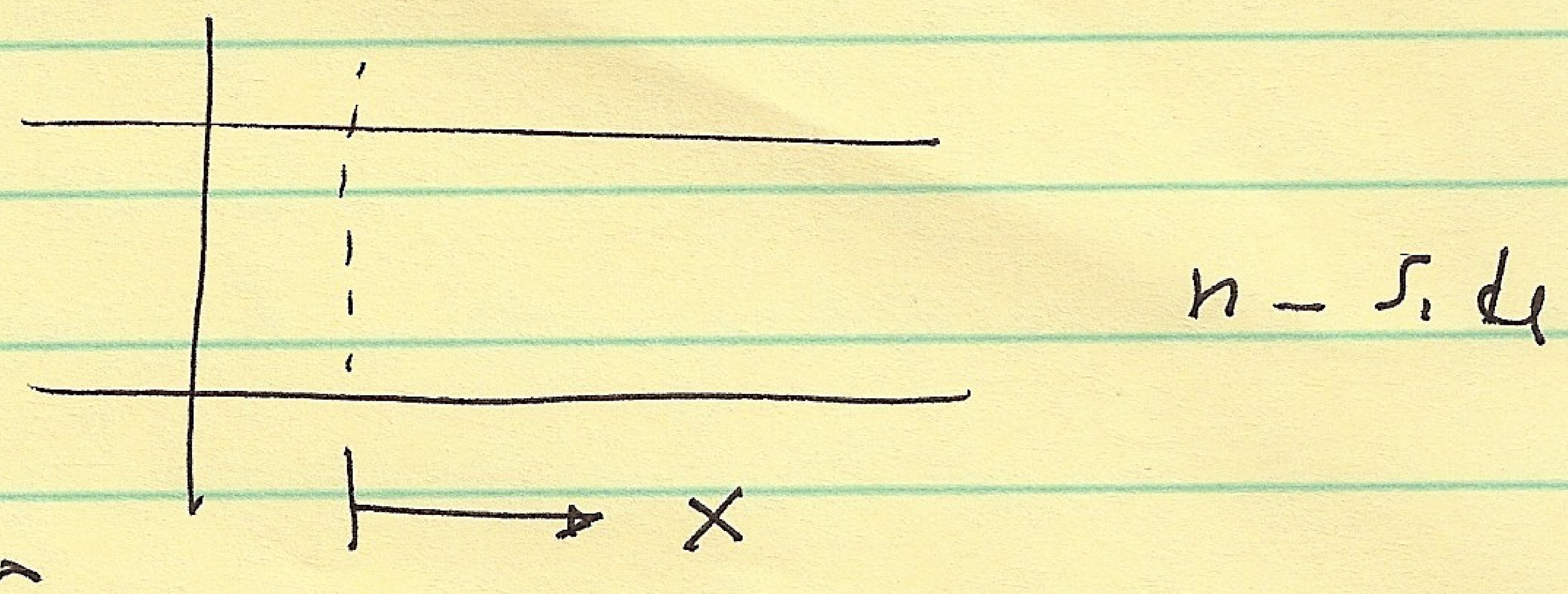
6

A a) Neglect absorption in the p^+ region since recombination will be fast. By instructions, neglect depletion region.

In steady state



(1) $$0 = D\frac{d^2\delta p}{dx^2} - \frac{\delta p}{\tau} + G_L$$

We expect $\delta p = A e^{-x/L} + B e^{x/L} + C$.
The middle term blows up for $x \sim$ many $\times L$.
$\Rightarrow B \to 0$. Substitute δp into Eq^n (1). Then

$$\frac{D}{L^2} A e^{-x/L} - \frac{A e^{-x/L}}{\tau} + -\frac{C}{\tau} + G_L = 0$$

For this to be true, require $L^2 = D\tau$ and $C = G_L \tau$

$$\underline{\delta p = A e^{-x/L}} + G_L \tau \quad \text{and} \quad L^2 = D\tau$$

At $x = 0$, expect $\delta p(0) = p_{no}\left(e^{qV/kT} - 1\right)$

$$= \frac{n_i^2}{N_D}\left(e^{qV/kT} - 1\right)$$

(8)

$$\delta p(0) = A + G_L \tau$$

$$A = \delta p(0) - G_L \tau$$

$$\delta p = (\delta p(0) - G_L \tau)\, e^{-x/L} + G_L \tau$$

Then $$J(0) = -qD \left.\frac{d\delta p}{dx}\right|_0$$

$$= +qD \frac{(\delta p(0) - G_L \tau)}{L}$$

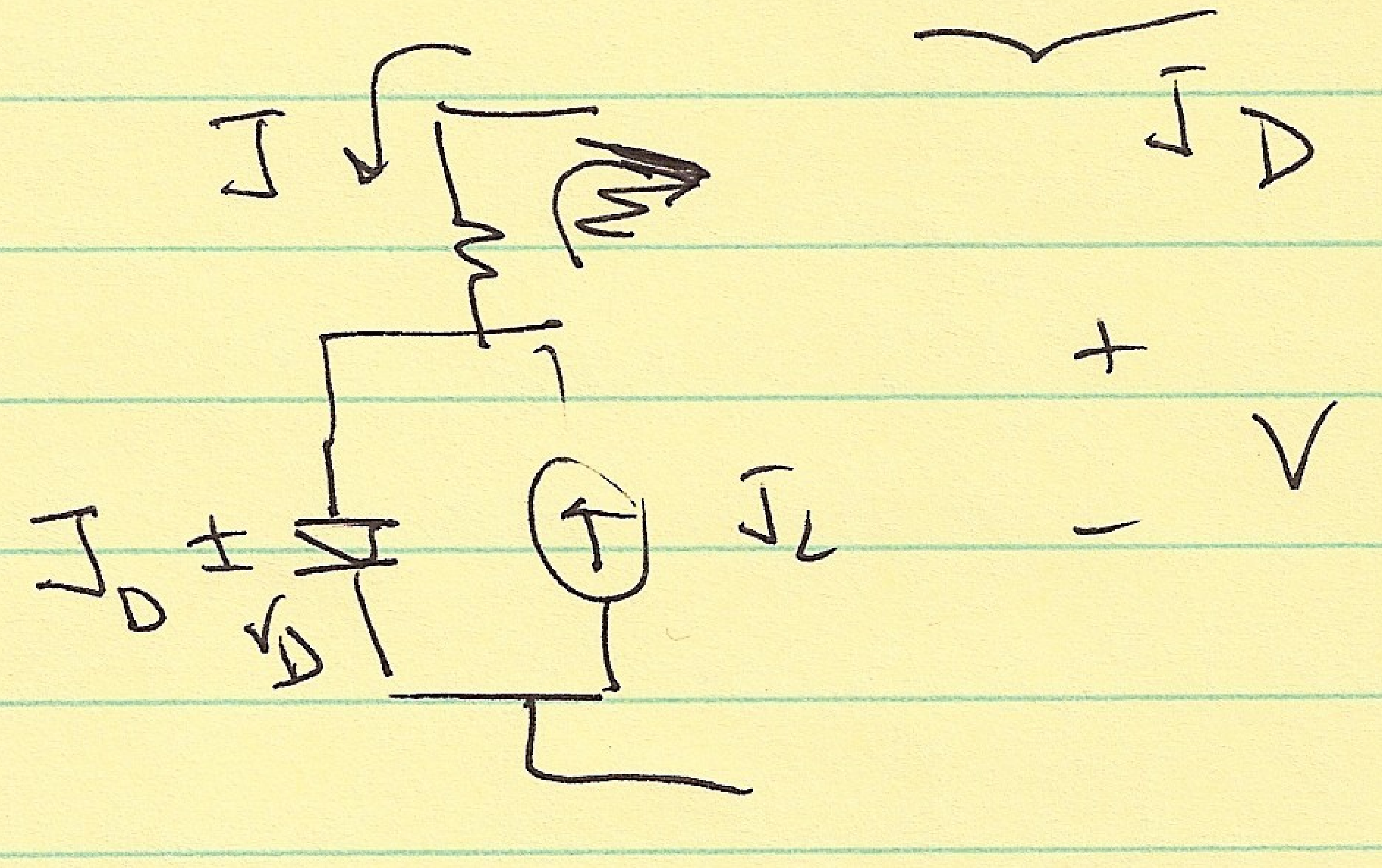
$$= qD \frac{\delta p(0)}{L} - \frac{qDG_L\tau}{L}$$

b) $$J = \frac{qD}{L}\frac{n_i^2}{N_D}\left(e^{qV/kT} - 1\right) - qG_L L$$

usual diode Eq^n → J_D

EH pairs absorbed with L of depletion region $= J_L$

c)



$$-V + JR + V_D = 0$$

$$V_D = V - JR$$

$$J = J_0\left(e^{(V-JR)/kT} - 1\right) - J_L$$

(3)

B c) The irradiance is $0.4\ W/m^2\,nm$ between 300 and 2500 nm. The # photons is

$$\frac{hc}{\lambda} N(\lambda) = P(\lambda) \Rightarrow N(\lambda) = \frac{\lambda}{hc} P(\lambda)$$

$N(\lambda)$: $\#/m^2\,nm$

$$\lambda_G = \frac{hc}{1.4\,eV} = 888\ nm$$

$$J_L = q \int_{300\,nm}^{888} \frac{\lambda}{hc} P(\lambda) \times 10^9\, d\lambda$$

$$= q \frac{(0.4)\,10^9}{hc} \frac{\lambda^2}{2} \Bigg|_{300\times10^{-9}}^{888\times10^{-9}}$$

$J_L = 112\ A/m^2$ or $0.0112\ A/cm^2$

or $11.2\,mA/cm^2$

$$J_s = 6.03\times10^7\, e^{-1.4/.0259}$$
$$= 2.018\times10^{-16}\ A/m^2$$

$$V_{oc} = V_T \ln\left(\frac{J_L}{J_s}+1\right) = .0259 \ln\left(\frac{112}{2.018\times10^{-16}}+1\right)$$

$V_{oc} = 1.058\ V$

(4)

~~P = J · V~~

$$P = JV$$
$$= \left[2.018 \times 10^{-16} \left(e^{V/V_T} - 1\right) - 112\right] \cdot V$$

P	V
+150.2	1
100.6	0.9
+89.6	.8
104.8	.95

$$\eta \sim \frac{104.8 \ W/m^2}{(.4)(2500-300)} = 11.9\ \%$$