dt

Q1)

$$\frac{np - n_i^2}{\tau_n(p + p_t) + \tau_p(n + n_t)}$$

$$n_t = n_i \exp\{(E_T - E_i)/kT\}$$

$$p_T = n_i \exp\{(E_i - E_T)/kT\}$$

$$\frac{np - n_i^2}{\tau_n(p + n_i \exp(E_i - E_T/kT)) + \tau_p(n + n_i \exp(E_T - E_i/kT))}$$

$$\frac{dR}{dE_T} = 0 \quad -\tau_n \frac{1}{kT} \exp\left(\frac{E_i - E_T}{kT}\right) + \frac{\tau_p}{kT} \exp\left(\frac{E_T - E_i}{kT}\right)$$

$$\tau_n \exp\left(\frac{E_i - E_T}{kT}\right) = \tau_p \exp\left(\frac{E_T - E_i}{kT}\right)$$

$$\frac{\tau_n}{\tau_p} = \exp\left(\frac{2(E_T - E_i)}{kT}\right)$$

$$\ln\left(\frac{\tau_n}{\tau_p}\right) = 2\left(\frac{E_T - E_i}{kT}\right)$$

$$E_T = \frac{kT}{2} \ln\frac{\tau_p}{\tau_n} + E_i$$

$10^{14} = x^{2}$

Q12) $\frac{dn}{dt} = \frac{dp}{dt} = -\frac{\Delta n}{\tau_{eff}} + G_{ex}$

$n + \Delta n = p + \Delta p$

in steady state,

$\Delta n = \tau_{eff} \cdot G_{ex}$

$N_D = 10^{17} = n_0$

$P_0 = 10^{3}$ low level injection

$\Delta n = 1.0 \times 10^{-6} \times 10^{20} = 10^{15}$

$\Delta p = 10^{15}$

$10^{17} = n_i e^{\frac{(E_{fn} - E_i)}{KT}}$

$10^{15} = n_i e^{\left(\frac{E_i - E_{FP}}{KT}\right)}$

b) $N_D = 10^{13} = n_0$

$\Delta n = 3 \times 10^{17}$

$P_0 = 10^{7}$

$G = \frac{np - n_i^2}{\tau (p + p_t + n + n_t)}$

$\frac{\Delta n}{\tau}$

$G = \frac{(n_0 + \Delta n)(P_0 + \Delta p) - n_i^2}{\tau (P_0 + \Delta p + p_i + n_0 + \Delta n + n_i)}$

$$0 = G - (n+\Delta n)(P+\Delta P) - n_i^2 \qquad n_i^2 << x^2$$

assume

$$G - x^2 - n_i^2 = 0$$

$$G = \frac{(10^{13}+\Delta n)(10^{7}+\Delta n) - 10^{20}}{10^{-5}\left(10^{7} + \cancel{10}\,2\Delta n + \cancel{10^{10}} + \cancel{10^{10}} + 10^{13}\right)}$$

$$10^{20} = G = \frac{10^{13}\Delta n + \Delta n^2}{10^{-5}\left(10^{13} + 2\Delta n\right)}$$

$$10^{15} = \frac{10^{13}\Delta n + \Delta n^2}{(10^{13} + 2\Delta n)}$$

$$10^{28} + 2\times10^{15}\Delta n = 10^{13}\Delta n + \Delta n^2$$

$$\Delta n^2 - 2\times10^{15}\Delta n - 10^{28} = 0$$

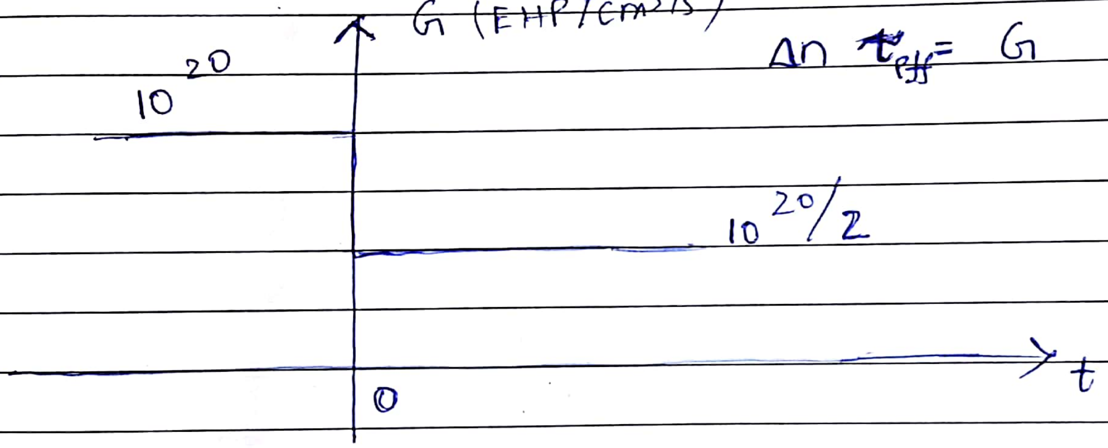
$$\frac{2\times10^{15} \pm \sqrt{4\times10^{30} + 4\times10^{28}}}{2}$$

$$\approx \frac{2\times10^{15} + 2\times10^{15}}{2}$$

$$2\times10^{15}$$

3)a) Low level for $N_D = 10^{17}\ cm^{-3}$ as $\Delta n << N_D$

$\Delta n\ \tau_{eff} = G$ at S:S



for $N_D = 10^{17}$, low level.

$\Rightarrow$ exponential decay.

$\Delta n(0) = 10^{15}$

$\Delta n(\infty) = 10^{15}/2$

$\Delta n(t) = [\Delta n(0) - \Delta n(\infty)]e^{-t/\tau} + \Delta n(\infty)$