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1. a). $\rho = \frac{1}{\sigma} = 10^{-1}\ \Omega\cdot cm$

From the figure, we can get donor impurity is around $7\times10^{16}\ cm^{-3}$.

$\sigma = q\mu_n N_d \Rightarrow \mu_n = \frac{\sigma}{eN_d} = \frac{10}{1.6\times10^{-19}\times7\times10^{16}} = 892.9\ cm^2/V\text{-}s$

b). From the figure, we can get acceptor impurity is around $9\times10^{16}\ cm^{-3}$

$\sigma = q\mu_p N_a \Rightarrow \mu_p = \frac{\sigma}{eN_a} = \frac{1}{e\rho N_a} = \frac{1}{1.6\times10^{-19}\times0.2\times9\times10^{16}} = 347.2\ cm^2/V\text{-}s$

2. $\rho = \frac{1}{\sigma} = \frac{1}{q(\mu_n n + \mu_p p)}$

a). $\mu_n \approx 1350\ cm^2/V\text{-}s$, $\mu_p \approx 480\ cm^2/V\text{-}s$

$\rho = \frac{1}{e(\mu_n+\mu_p)n_i} = \frac{1}{1.6\times10^{-19}(1350+480)\times1.5\times10^{10}} = 2.28\times10^5\ \Omega\cdot cm$

b). $\mu_n \approx 1200\ cm^2/V\text{-}s$, $\mu_p \approx 400\ cm^2/V\text{-}s$

$\rho = \frac{1}{e(\mu_n+\mu_p)n_i} = \frac{1}{1.6\times10^{-19}(1200+400)\times1.5\times10^{10}} = 2.60\times10^5\ \Omega\cdot cm$

c). $\mu_n \approx 300\ cm^2/V\text{-}s$, $\mu_p \approx 100\ cm^2/V\text{-}s$

$\rho = \frac{1}{e(\mu_n+\mu_p)n_i} = \frac{1}{1.6\times10^{-19}(300+100)\times1.5\times10^{10}} = 1.04\times10^6\ \Omega\cdot cm$

3. a). $J = e(p_0\mu_p + n_0\mu_n)E$

$n_0 = N_d - N_a = 10^{14}\ cm^{-3}$

$J = 1.6\times10^{-19}\times10^{14}\times1000\times100 = 1.6\ A/cm^2$

b). $n_0 = 1.05\times10^{14}\ cm^{-3}$ now.

$n_0 = \frac{(N_d-N_a)}{2} + \sqrt{\left(\frac{N_d-N_a}{2}\right)^2 + n_i^2} \Rightarrow n_i^2 = 5.25\times10^{26}$

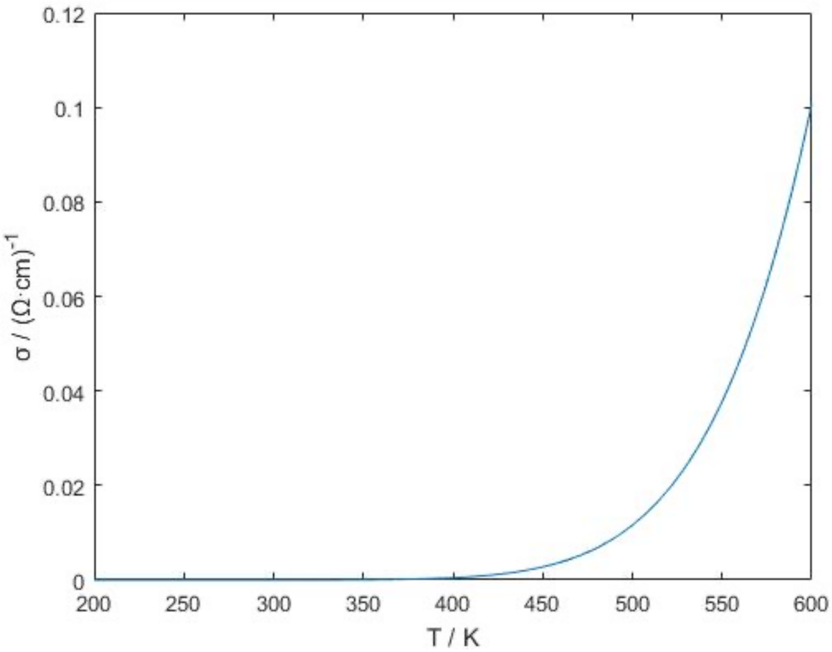
$n_i^2 = N_cN_v\exp\left(-\frac{E_g}{kT}\right) \Rightarrow 5.25\times10^{26} = 2\times10^{19}\times10^{19}\times\left(\frac{T}{300}\right)^3\exp\left(\frac{-1.1}{0.0259\,T/300}\right)$

We can get $T = 456\ K$

4. $n_i = \sqrt{N_C N_v}\ \exp\left(-\frac{E_g}{2kT}\right)$

$\sigma = e(\mu_n+\mu_p)n_i = 1.6\times10^{-19}\times 1830\times\left(\frac{T}{300}\right)^{-\frac{3}{2}}\times\sqrt{2.8\times10^{19}\left(\frac{T}{300}\right)^{\frac{3}{2}}\times 1.04\times10^{19}\left(\frac{T}{300}\right)^{\frac{3}{2}}}\ \exp\left(-\frac{1.12}{2kT}\right)$

$= 1.6\times10^{-19}\times 1830\times10^{19}\times\left(\frac{T}{300}\right)^{-\frac{3}{2}}\times\left(\frac{T}{300}\right)^{\frac{3}{2}}\times\sqrt{2.8\times1.04}\ \exp\left(-\frac{1.12}{2\times0.0259\times T/300}\right)$




5. $J = eD_n\frac{dn}{dx} = 1.6\times10^{-19}\times 27\times\frac{5\times10^{15}-2\times10^{16}}{0.012-0} = -5.4\ A/cm^2$

6. a). $E_x = -\left(\frac{kT}{e}\right)\cdot\frac{1}{N_d(x)}\cdot\frac{dN_d(x)}{dx}$

$= -0.0259\times\frac{1}{N_{d0}e^{-\frac{x}{L}}}\times N_{d0}e^{-\frac{x}{L}}\times -\frac{1}{L}$

$= 0.0259\times\frac{1}{10\times10^{-4}} = 25.9\ V/cm$

b). $\phi = -\int_0^L E_x\,dx = -25.9\times10\times10^{-4} = -2.59\times10^{-2}\ V$