6.2 GaAs, at $T = 300$ K, is uniformly doped with acceptor impurity atoms to a concentration of $N_a = 2 \times 10^{16}$ cm^{-3}. Assume an excess carrier lifetime of 5×10^{-7}s. (*a*) Determine the electron–hole recombination rate if the excess electron concentration is $\delta n = 5 \times 10^{14}$ cm^{-3}. (*b*) Using the results of part (*a*), what is the lifetime of holes?

- First, find the electron concentration at thermal equilibrium.

Table B.4, $n_i = 1.8 \times 10^6$ #/cm^3

Since $N_a >> n_i$, $p_0 \simeq N_a = 2 \times 10^{16}$ #/cm^3

Per (4.43), $n_0 = \frac{n_i^2}{p_0} = \frac{(1.8 \times 10^6)^2}{2 \times 10^{16}} \Rightarrow \underline{n_0 = 1.62 \times 10^{-4} \text{ #/cm}^3}$

a) Per (6.14), $R_n' = R_p' = \frac{\delta n(t)}{\tau_{p0}} = \frac{5 \times 10^{14} \text{ cm}^{-3}}{5 \times 10^{-7} \text{ s}}$

$$\underline{R_n' = R_p' = 1 \times 10^{21} \frac{\#}{\text{cm}^3 \text{s}}}$$

b) Per (6.35), $R_p = \frac{p}{\tau_{pt}} = \frac{n}{\tau_{nt}}$

$\tau_{pt} = \frac{\tau_{nt}}{n} p$ for minority carriers

$\tau_{nt} \simeq \tau_{n0} = 5 \times 10^{-7}$ s

$n \simeq n_0 = 1.62 \times 10^{-4}$ #/cm^3

$p \simeq p_0 = 2 \times 10^{16}$ #/cm^3

$\tau_{pt} = \frac{5 \times 10^{-7}}{1.62 \times 10^{-4}} (2 \times 10^{16}) \Rightarrow \underline{\tau_{pt} = 6.173 \times 10^{13} \text{ s}}$

$\Rightarrow$ long time as there are many many more holes than electrons.