6.9 A silicon sample at $T = 300$ K has a uniform acceptor concentration of 7×10^{15} cm^{-3}. The excess carrier lifetime is $\tau_{n0} = 10^{-7}$ s. (*a*) Determine the ambipolar mobility. (*b*) Find the ambipolar diffusion coefficient. (*c*) What are the electron and hole lifetimes?

- First, find the electron and hole concentrations at thermal equilibrium.

From Table B.4, $n_i = 1.5 \times 10^{10}$ #/cm^3 for Si @ 300 K.

Since $N_a >> n_i$, $p_0 \simeq N_a = 7 \times 10^{15}$ #/cm^3

Per (4.43), $n_0 = \frac{n_i^2}{p_0} = \frac{(1.5\times10^{10})^2}{7\times10^{15}} \Rightarrow n_0 = 32{,}142.86$ #/cm^3

a) For p-type semiconductor w/ low-level injection (6.46) $\mu' = \mu_n$. Using Fig. 5.3 w/ $N_I = N_a$, yields $\mu' = \mu_n = 1700 \frac{cm^2}{V\cdot s}$

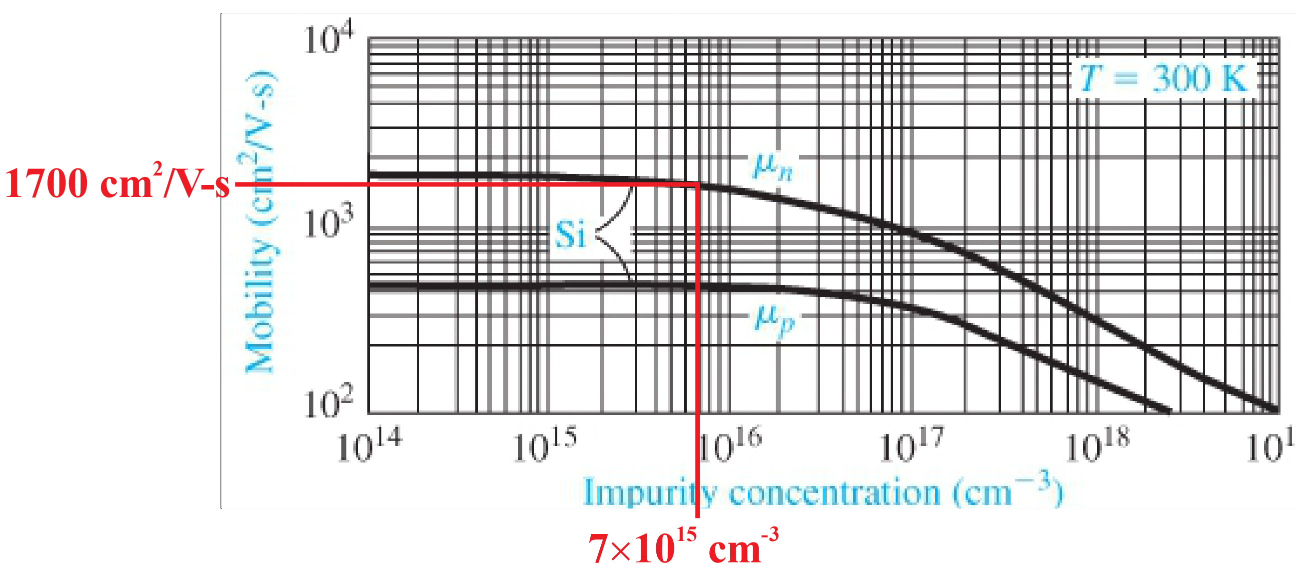

Fig. 5.3

Note: Table 5.1, gives $\mu_n = 1350$ cm^2/V·s at low doping levels.

b) Per (6.45), $D' = D_n$. Use Einstein Relation

(5.47) $\frac{D_n}{\mu_n} = \frac{k_B T}{e} \Rightarrow D_n = \mu_n \frac{k_B T}{e}$

$D_n = 1700 \frac{8.617333 \times 10^{-5} eV/K (300K)}{e}$

$$\Rightarrow \underline{\underline{D_n = 43.95 \frac{cm^2}{s}}}$$

c) Given electron lifetime $\underline{\underline{\tau_{n0} = \tau_{nt} = 10^{-7} s}}$

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

$\hookrightarrow \tau_{pt} = \frac{\tau_{nt}}{n_0} p_0 = \frac{10^{-7} s}{32,143} 7 \times 10^{15}$

$$\underline{\underline{\tau_{pt} = 21,777.8 \text{ s}}}$$

$\Rightarrow$ Holes last a <u>long time</u> since $p_0 >> n_0$.