#1. Consider silicon at $T = 300$ K. (a) Calculate $n_0$ for (i) $E_c - E_F = 0.2$ eV, (ii) $E_c - E_F = 0.3$ eV, and (iii) $E_c - E_F = 0.4$ eV. (b) Calculate $p_0$ for (i) $E_F - E_v = 0.2$ eV, (ii) $E_F - E_v = 0.3$ eV, and (iii) $E_F - E_v = 0.4$ eV. 

For each case above, draw the energy band model showing $E_c$, $E_v$, and $E_F$. Write numeric values for (1), (2), and (3) for each case.

#2. The electron concentration in silicon is $n_0 = 3 \times 10^4$ cm$^{-3}$. (a) Determine $p_0$. (b) Is this material n or p type? (c) Determine $E_F - E_v$.

#3. The electron concentration in silicon at $T = 375$ K is $n_0 = 3 \times 10^{16}$ cm$^{-3}$. (a) Determine $p_0$. (b) Is this material n or p type? (c) Determine $E_c - E_F$.

#4. Consider a germanium semiconductor at $T = 300$ K. Calculate the thermal equilibrium concentrations of $n_0$ and $p_0$ for (a) $N_n = 10^{16}$ cm$^{-3}$, $N_d = 0$, and (b) $N_d = 5 \times 10^{15}$ cm$^{-3}$, $N_a = 0$.

#5. Assume that silicon, germanium, and gallium arsenide each have dopant concentrations of $N_d = 1 \times 10^{13}$ cm$^{-3}$ and $N_a = 2.5 \times 10^{13}$ cm$^{-3}$ at $T = 300$ K. For each of the three materials (a) Is this material n type or p type? (b) Calculate $n_0$ and $p_0$.

#6. A silicon semiconductor at $T = 300$ K is homogeneously doped with $N_d = 5 \times 10^{15}$ cm$^{-3}$ and $N_a = 0$. (a) Determine the thermal equilibrium concentrations of free electrons and free holes. (b) Calculate the drift current density for an applied $E$-field of 30 V/cm. (c) Repeat parts (a) and (b) for $N_d = 0$ and $N_a = 5 \times 10^{16}$ cm$^{-3}$.

(a) A silicon semiconductor is in the shape of a rectangular bar with a cross-sectional area of 10 $\mu$m $\times$ 10 $\mu$m, a length of 0.1 cm, and is doped with $5 \times 10^{16}$ cm$^{-3}$ arsenic atoms. The temperature is $T = 300$ K. Determine the current if 5 V is applied across the length. (b) Repeat part (a) if the length is reduced to 0.01 cm. (c) Calculate the average drift velocity of electrons in parts (a) and (b).