1. Consider a semiconductor in which \( n_0 = 10^{15} \text{ cm}^{-3} \) and \( n_i = 10^{10} \text{ cm}^{-3} \). Assume that the excess carrier lifetime is \( 10^{-6} \text{ sec} \). Determine the electron hole recombination rate if the excess hole concentration is \( \Delta p = 5 \times 10^{13} \text{ cm}^{-3} \).

2. Calculate the applied reverse bias voltage at which the ideal reverse current in a pn junction diode at \( T=300 \text{ K} \) reaches 90 percent of its reverse saturation current value.

3. Consider a p+n silicon diode at \( T=300 \text{ K} \) with doping concentrations of \( N_a = 10^{18} \text{ cm}^{-3} \) and \( N_d = 10^{16} \text{ cm}^{-3} \). The minority carrier hole diffusion coefficient is \( D_p = 12 \text{ cm}^2/\text{sec} \), and minority carrier hole lifetime is \( \tau_p = 10^{-7} \text{ sec} \). The cross sectional area \( A = 10^{-4} \text{ cm}^2 \). Calculate the reverse saturation current and the diode current at a forward bias voltage of \( 0.50 \text{ V} \).

4. Consider an ideal silicon pn junction diode with the following parameters: \( \tau_{n0} = \tau_{p0} = 0.1 \times 10^{-6} \text{ sec} \), \( D_n = 25 \text{ cm}^2/\text{sec} \), \( D_p = 10 \text{ cm}^2/\text{sec} \). What must be the ratio of \( N_a / N_d \) so that 95 percent of the current in the depletion region is carried by electrons?

5. A germanium p+n diode at \( T=300 \text{ K} \) has the following parameters: \( N_a = 10^{18} \text{ cm}^{-3} \), \( N_d = 10^{16} \text{ cm}^{-3} \), \( D_p = 10 \text{ cm}^2/\text{sec} \), \( D_n = 25 \text{ cm}^2/\text{sec} \), \( \tau_p = 10^{-6} \text{ sec} \), \( \tau_n = 10^{-6} \text{ sec} \) and \( A = 10^{-4} \text{ cm}^2 \). Determine the diode current for (a) a forward bias voltage of \( 0.2 \text{ V} \) and (b) a reverse bias voltage of \( 0.2 \text{ V} \).