ECE 305 Homework: Week 3

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1) Assume Silicon (bandgap 1.12 eV) at room temperature (300 K) with the Fermi level located exactly in the middle of the bandgap. Answer the following questions.

a) What is the probability that a state located at the bottom of the conduction band is filled?

b) What is the probability that a state located at the top of the valence band is empty?

2) For Si at room temperature, calculate the following quantities. (Numerical answers required, and don’t forget to include units with your answers).

a) The density of states in the conduction band, \( g_C(E) \), at an energy 26 meV above \( E_C \).

b) The density of states in the valence band, \( g_V(E) \), at an energy 26 meV below \( E_v \).

c) The effective density of conduction band states, \( N_C \).

d) The effective density of valence band states, \( N_V \).

e) Compute the ratio of the effective density of conduction band states to the atomic density of Si.

3) Consider a region of Si at room temperature. For each of the following cases, calculate the equilibrium electron and hole concentrations (\( n \) and \( p \)). Assume that the dopants are fully ionized.

a) Intrinsic material (\( N_D = N_A = 0 \))

b) \( N_D = 1.00 \times 10^{13} \text{ cm}^{-3} \) \( N_A = 0 \)

c) \( N_D = 1.00 \times 10^{17} \text{ cm}^{-3} \) \( N_A = 0 \)

d) \( N_D = 0 \) \( N_A = 1.00 \times 10^{17} \text{ cm}^{-3} \)

e) \( N_D = 1.00 \times 10^{17} \text{ cm}^{-3} \) \( N_A = 3.00 \times 10^{17} \text{ cm}^{-3} \)

4) Assuming silicon with completely ionized dopants, compute \( n \) and \( p \) for the following case.

\( N_D = 5.00 \times 10^{16} \text{ cm}^{-3} \)

\( N_A = 0 \)

\( T = 700 \text{ K} \)
HW3 (continued):

5) This problem asks you to compute the location of the Fermi level.

5a) For each of the cases (a-e) in Prob. 3, calculate the Fermi level position, with respect to the intrinsic level \( E_F - E_i \). Note that you need to consider the sign.

5b) For each of the cases (a-e) in Prob. 3, calculate the Fermi level position, with respect to the bottom of the conduction band \( E_F - E_C \). Note that you need to consider the sign.

5c) For the case of problem 4), calculate the Fermi level position, with respect to the intrinsic level \( E_F - E_i \). Note that you need to consider the sign.