

Homework #3

Solution

1. a) $N_D = 10^{15} \text{ cm}^{-3}$

$$E_F - E_C = KT \ln \left(\frac{n}{N_C} \right)$$

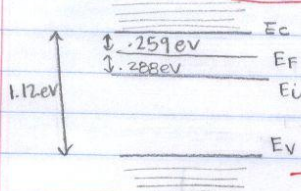
$$E_F - E_C = 0.025 \text{ eV} \ln \left[\frac{10^{15}}{(2.51 \times 10^{19})(1.18)^{3/2}} \right]$$

$$E_F - E_C = -0.259 \text{ eV}$$

$$E_F - E_i = KT \ln \left(\frac{N_D}{n_i} \right)$$

$$E_F - E_i = 0.025 \text{ eV} \ln \left(\frac{10^{15}}{10^{10}} \right)$$

$$E_F - E_i = 0.288 \text{ eV}$$



b) $N_A = 10^{17} \text{ cm}^{-3}$

$$E_V - E_F = KT \ln \left(\frac{p}{N_V} \right)$$

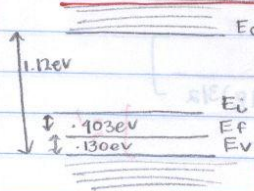
$$E_V - E_F = 0.025 \text{ eV} \ln \left[\frac{10^{17}}{(2.51 \times 10^{19})(0.81)^{3/2}} \right]$$

$$E_V - E_F = -0.130 \text{ eV}$$

$$E_C - E_F = KT \ln \left(\frac{N_A}{n_i} \right)$$

$$E_C - E_F = 0.025 \text{ eV} \ln \left(\frac{10^{17}}{10^{10}} \right)$$

$$E_C - E_F = 0.403 \text{ eV}$$



2. a) $n_i = \sqrt{N_c N_v} e^{-E_g/2KT}$

$$n_i = \sqrt{(2.51 \times 10^{19})^2 (1.18)^{3/2} (0.81)^{3/2}} e^{-1.12/2(0.617 \times 10^{-5})(273)}$$

$$n_i = 11.1 \times 10^8 \text{ cm}^{-3}$$

$$n_i = p_i = 11.1 \times 10^8 \text{ cm}^{-3}$$

12.5'

b) $n_i = \sqrt{N_c N_v} e^{-E_g/2KT}$

$$n_i = \sqrt{(2.51 \times 10^{19})^2 (1.18)^{3/2} (0.81)^{3/2}} e^{-1.12/2(0.617 \times 10^{-5})(273)}$$

$$n_i = 6.58 \times 10^{11} \text{ cm}^{-3}$$

$$n_i = p_i = 6.58 \times 10^{11} \text{ cm}^{-3}$$

12.5'

3. a) $E_F - E_c = -.25 \text{ eV}$

$$E_F - E_c = KT \ln \left(\frac{n}{N_c} \right)$$

$$-.25 = 0.025 \ln \left[\frac{n}{(2.51 \times 10^{19})(1.18)^{3/2}} \right]$$

$$n = 4.90 \times 10^{14} \text{ cm}^{-3}$$

$$\rho \approx 10 \Omega \cdot \text{cm} \rightarrow \text{from graph p. 86}$$

15'

b) $\mu_n \approx 1300 \text{ cm}^2/\text{v-s} \rightarrow \text{from graph p. 80}$

10'

4. a) $\rho = \frac{1}{q \mu_p N_a}$

$$\rho = \frac{1}{(1.6 \times 10^{-19})(380)(1.8 \times 10^{17})}$$

$$\rho = .021 \Omega \cdot \text{cm} \quad - \quad] 5'$$

b) $E_F - E_c = KT \ln \left(\frac{n}{N_c} \right)$

$$E_F - E_c = 0.025 \ln \left[\frac{8 \times 10^{17}}{(2.51 \times 10^{19})(1.18)^{3/2}} \right]$$

$$E_F - E_c = -.0924 \text{ eV}$$

5'

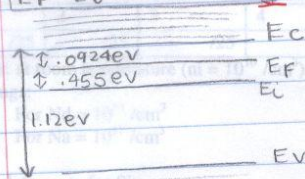
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$$E_F - E_C = kT \ln \left(\frac{N_D}{n_i} \right)$$

$$E_F - E_C = 0.025 \ln \left(\frac{8 \times 10^{17}}{10^{10}} \right)$$

$$E_F - E_C = .455 \text{ eV}$$



	Total
E_C	725
E_F	7100
E_V	

5'

10'

- Calculate n_i at $T = 300 \text{ K}$.
 - When temperature is 300 degree Celsius.
 - When temperature is 100 degree Celsius.
- Given a Si semiconductor that has its Fermi level $0.25E_g$ below the conduction band.
 - Find the resistivity in (Ohm-cm) .
 - Find the electron mobility in $(\text{cm}^2/\text{V-s})$.
- Given a p -type semiconductor that has (μ_n) of $380 \text{ cm}^2/\text{V-s}$.
 - Find the resistivity in (Ohm-cm) .
 - Draw a band diagram (as in Problem #1) and indicate your findings.