Problem 1.1) $T = 295K$

$N_a = 5 \times 10^{17} cm^{-3}$ $T = 280K$; $300K$; $330K$

What is the electron concentration?

What is the whole concentration?

$q = 1.602 \times 10^{-19} C$

in intrinsic semiconductor $p_i = n_i$

Extrinsic Semiconductor $n_0 p_0 = n_i^2$ $N_a >> n_i$

$n_0 \approx N_D$ $p_0 \approx \frac{n_i^2}{N_D}$ | $p_0 \approx N_a$ $n_0 \approx \frac{n_i^2}{N_A}$

Calculate n_i @ different temperatures

$$n_i = A_1 T^{3/2} \exp(-A_2/t)$$

$$= 7 \times 10^{15}\ K^{-3/2}\ cm^{-3} \cdot (280K)^{+3/2}$$

$$\cdot \exp\left[\frac{-6600K}{295K}\right]$$

$n_i = 1.900 \times 10^{9}$ cm^{-3} @ 280K

$n_i = 6.814 \times 10^{9}$ cm^{-3} @ 295K

$n_i = 1.0146 \times 10^{10}$ cm^{-3} @ 300K

$n_i = 8.649 \times 10^{10}$ cm^{-3} @ 330K

Calculate no using n_i and N_a

$$n_0 \approx \frac{n_i^2}{N_a} \approx \frac{(1.900 \times 10^{9})^2}{5 \times 10^{17}} = 7.22 \quad @\ 280K$$

$$n_0 \approx \frac{n_i^2}{N_a} \approx \frac{(6.814 \times 10^{9})^2}{5 \times 10^{17}} = 92.96 \quad @\ 295K$$

$$n_0 \approx \frac{(1.0146 \times 10^{10})^2}{5 \times 10^{17}} = 205.88 @ 300K \qquad n_0 \approx \frac{(8.649 \times 10^{10})^2}{5 \times 10^{17}} = 14967.04$$

Final answer

Temp	P_0	n_0
280 K	5×10^{17} cm^{-3}	7.22 cm^{-3}
295 K	5×10^{17} cm^{-3}	92.86 cm^{-3}
300 K	5×10^{17} cm^{-3}	205.88 cm^{-3}
330 K	5×10^{17} cm^{-3}	14.961×10^{3} cm^{-3}

HW 1.2

n_0 ? p_0 ? @ 27°C

1) • $1 \times 10^{16}\ cm^{-3}$ Boron → acceptor

$$p_0 \simeq 1 \times 10^{16}\ cm^{-3}$$

$$n_i = A_c \cdot T^{3/2} \exp\left(\frac{-A_2}{T}\right)$$

$$= 7 \times 10^{15} \cdot 300^{3/2} \exp\left(\frac{-6600}{300}\right)$$

$$= 1.01466 \times 10^{10}\ cm^{-3}$$

$$n_0 \simeq \frac{n_i^2}{N_A} = \frac{(1.01466 \times 10^{10})^2}{1 \times 10^{16}} = 10.294 \times 10^{3}\ cm^{-3}$$

$$p_0 = 1 \times 10^{16}\ cm^{-3} \qquad n_0 = 10.294 \times 10^{3}\ cm^{-3}$$

$$p_0 = n_i \exp\left(\frac{E_i - E_f}{kT}\right)$$

$$\frac{p_0}{n_i} = \exp\left(\frac{E_i - E_f}{kT}\right)$$

$$\ln\left(\frac{p_0}{n_i}\right) = \frac{E_i - E_f}{kT}$$

$$kT \cdot \ln\left(\frac{p_0}{n_i}\right) = E_i - E_f$$

$$E_f = E_i - kT \cdot \ln\left(\frac{p_0}{n_i}\right)$$

$$E_f = 0.56\ eV - 8.62 \times 10^{-5} \times 300 \ln\left(\frac{1 \times 10^{16}}{1.014 \times 10^{10}}\right)$$

$$E_f = 0.203106$$

2)

$$N_D = 3 \times 10^{16}\ cm^{-3}$$

$$N_A = 2.9 \times 10^{16}\ cm^{-3}$$

$$N_{D\,total} = N_D - N_A = 3 \times 10^{16} - 2.9 \times 10^{16} = 0.1 \times 10^{16}$$

$$N_{D\,total} = 0.1 \times 10^{16}\ cm^{-3} = 1 \times 10^{15}\ cm^{-3}$$

$$n_0 \approx N_D = 1 \times 10^{15}\ cm^{-3}$$

$$p_0 \approx \frac{n_i^2}{N_D} = \frac{(1.0146 \times 10^{10}\ cm^{-3})^2}{1 \times 10^{15}\ cm^{-3}}$$

$$p_0 \approx 10.294 \times 10^{4}\ cm^{-3}$$

$$n_0 = 1 \times 10^{15}\ cm^{-3} \qquad p_0 = 10.294 \times 10^{4}\ cm^{-3}$$

$$n_0 = n_i \exp\left(\frac{E_f - E_i}{kT}\right)$$

$$\frac{n_0}{n_i} = \exp\left(\frac{E_f - E_i}{kT}\right)$$

$$\ln\left(\frac{n_0}{n_i}\right) = \frac{E_f - E_i}{kT}$$

$$kT \ln\left(\frac{n_0}{n_i}\right) = E_f - E_i$$

$$E_f = kT \ln\left(\frac{n_0}{n_i}\right) + E_i$$

$$E_f = 300K * 8.62\times10^{-5}\frac{eV}{K} \ln\left(\frac{1\times10^{16}}{1.0146\times10^{10}}\right) + 0.56eV$$

$$E_f = 0.297eV + 0.56eV$$

$$E_f = 0.957eV$$

HW 1.3

a) $N_D = 10^{16}\ cm^{-3}$

$$\sigma = \frac{1}{\rho} = \mu_B \cdot n \cdot q$$

$$n = 10^{16}\ cm^{-3}$$

$$\sigma = 1,194 \frac{cm^2}{Vs} \cdot 10^{16} \frac{1}{cm^3} \cdot 1.6 \times 10^{-19}\ C$$

$$\sigma = 1.9104$$

$$\rho = \frac{1}{\sigma} = 0.52 \frac{Vs}{cm^2 C}$$

b) $$\frac{10^{16}\ cm^{-3} \times 31u}{5 \times 10^{22} cm^{-3} \times 28u} = 2,214 \times 10^{-7}$$

$$Ratio = 2.214 \times 10^{-7}$$