Q1

Calculate the intrinsic carrier density n_i for silicon at $T = 50$ K and 350 K.
Ans. 9.6×10^{-39}/cm^3; 4.15×10^{11}/cm^3

$$n_i = B \cdot T^{3/2} e^{-E_g/2kT}$$

$$B = 7.3 \times 10^{15} \text{ cm}^{-3} \text{ K}^{-3/2}$$

$$k = 8.62 \times 10^{-5} \text{ eV/K}$$

$$E_g = 1.12 \text{ eV for Si}$$

@ 50K $\rightarrow$ $n_i = (7.3 \times 10^{15})\, 50^{3/2}\, e^{-1.12/2k50}$

$= 9.63 \times 10^{-39}$ carriers/cm^3

@ 350K $\rightarrow$ $n_i = (7.3 \times 10^{15})\, 350^{3/2}\, e^{-1.12/2k350}$

$= 4.15 \times 10^{11}$ carrier/cm^3

Q2

For a silicon crystal doped with boron, what must N_A be if at $T = 300$ K the electron concentration drops below the intrinsic level by a factor of 10^6?
Ans. $N_A = 1.5 \times 10^{16}/\text{cm}^3$

$n_e = n_i / 10^6$

@ $T = 300K \Rightarrow n_i = 1.5 \times 10^{10}$ carriers/cm^3

$n_i^2 = n_e \cdot n_p = n_e \cdot N_A$

$n_i^2 = \frac{n_i}{10^6} \cdot N_A \Rightarrow N_A = n_i \cdot 10^6 = 1.5 \times 10^{16}\ \text{cm}^{-3}$