4.1 Calculate the intrinsic carrier concentration, n_i, at $T = 200$, 400, and 600 K for (*a*) silicon

- Also, find N_c, N_v, and k_BT at each temperature.

From Table B.4, $E_g = 1.12\,eV$, $m_n^* = 1.08 m_0$, $m_p^* = 0.56 m_0$

200 K $K_BT = 1.380649\times10^{-23}\,\frac{J}{K}(200K) = \underline{2.7613\times10^{-21}\,J}$

$= 8.617333\times10^{-5}\,\frac{eV}{K}(200K) = \underline{0.017235\,eV}$

(4.10) $N_c = 2\left(\frac{2\pi m_n^* K_BT}{h^2}\right)^{3/2}$

$= 2\left(\frac{2\pi\, 1.08(9.1093837\times10^{-31}\,1.380649\times10^{-23}}{(6.62607\times10^{-34})^2}\right)^{3/2}(200)^{3/2}$

$= 2.710165\times10^{21}(200)^{3/2} \Rightarrow \boxed{N_{c,200} = 1.5331\times10^{25}\,\frac{\#}{m^3} = 1.5331\times10^{19}\,\frac{\#}{cm^3}}$

(4.18) $N_V = 2\left(\frac{2\pi m_p^* K_BT}{h^2}\right)^{3/2}$

$= 2\left(\frac{2\pi\, 0.56(9.1093837\times10^{-31}\,1.380649\times10^{-23}}{(6.62607\times10^{-34})^2}\right)^{3/2}(200)^{3/2}$

$= 1.011911\times10^{21}(200)^{3/2} \Rightarrow \boxed{N_V = 5.72423\times10^{24}\,\frac{\#}{m^3} = 5.72423\times10^{18}\,\frac{\#}{cm^3}}$

(4.23) $n_i^2 = N_cN_V e^{-E_g/K_BT}$

$= (1.5331\times10^{25})\,5.72423\times10^{24}\,e^{-1.12/0.017235}$

$= 5.254474\times10^{21}$

$n_{i,200} = \sqrt{5.254474\times10^{21}} \Rightarrow \boxed{n_{i,200} = 7.24877\times10^{10}\,\frac{\#}{m^3} = 7.24877\times10^{4}\,\frac{\#}{cm^3}}$

400K $k_B T = 2(2.7613 \times 10^{-21}) = \underline{5.5226 \times 10^{-21}\ J}$

$= 2(0.017235) = \underline{0.034469\ eV}$

$N_c = 2.710165 \times 10^{21} (400)^{3/2}$

$\underline{N_c = 4.33626 \times 10^{25}\ \#/m^3 = 4.33626 \times 10^{19}\ \#/cm^3}$

$N_v = 1.011911 \times 10^{21} (400)^{3/2}$

$\underline{N_v = 1.61906 \times 10^{25}\ \#/m^3 = 1.61906 \times 10^{19}\ \#/cm^3}$

$n_i^2 = N_c N_v e^{-E_g/k_B T} = (4.33626 \times 10^{25})(1.61906 \times 10^{25}) e^{-1.12/0.034469}$

$n_i^2 = 5.43249 \times 10^{36} \Rightarrow$ $\boxed{n_{i,400} = 2.33077 \times 10^{18}\ \#/m^3 = 2.33077 \times 10^{12}\ \#/cm^3}$

600K $k_B T = 3(2.7613 \times 10^{-21}) = \underline{8.28389 \times 10^{-21}\ J}$

$= 3(0.017235) = \underline{0.051704\ eV}$

$N_c = 2.710165 \times 10^{21} (600)^{3/2}$

$\underline{N_c = 7.96623 \times 10^{25}\ \#/m^3 = 7.96623 \times 10^{19}\ \#/cm^3}$

$N_v = 1.011911 \times 10^{21} (600)^{3/2}$

$\underline{N_v = 2.9744 \times 10^{25}\ \#/m^3 = 2.9744 \times 10^{19}\ \#/cm^3}$

$n_i^2 = N_c N_v e^{-E_g/k_B T} = (7.96623)(2.9744)\, 10^{50}\, e^{-1.12/0.051704}$

$= 9.2697 \times 10^{41} \Rightarrow$ $\boxed{n_{i,600} = 9.62793 \times 10^{20}\ \#/m^3 = 9.62793 \times 10^{14}\ \#/cm^3}$