4.1 Calculate the intrinsic carrier concentration, n_i, at $T = 200$, 400, and 600 K for (*c*) gallium arsenide.

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

From Table B.4, $E_g = 1.42$ eV, $m_n^* = 0.067 m_0$, & $m_p^* = 0.48 m_0$

200 K $\quad k_BT = 8.617333 \times 10^{-5}(200) = 0.017235$ eV

$= 1.38065 \times 10^{-23}(200) = 2.7613 \times 10^{-21}$ J

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

$N_c = 2\left[\frac{2\pi\, 0.067(9.1093837\times10^{-31})\,1.380649\times10^{-23}}{(6.62607\times10^{-34})^2}\right]^{3/2} 200^{3/2}$

$= 8.37534 \times 10^{19}\,(200)^{3/2} \Rightarrow$ $N_c = 2.3689 \times 10^{23}\ \#/m^3 = 2.3689 \times 10^{17}\ \#/cm^3$

(4.18) $N_v = 2\left(\frac{2\pi m_p^* k_B T}{h^2}\right)^{3/2}$

$N_v = 2\left[\frac{2\pi\, 0.48(9.1093837\times10^{-31})\,1.380649\times10^{-23}}{(6.62607\times10^{-34})^2}\right]^{3/2} 200^{3/2}$

$= 1.60602 \times 10^{21}\,(200)^{3/2} \Rightarrow$ $N_v = 4.5425 \times 10^{24}\ \#/m^3 = 4.5425 \times 10^{18}\ \#/cm^3$

(4.23) $n_i^2 = N_c N_v\, e^{-E_g/k_BT}$

$n_i^2 = 2.3689 \times 10^{23}(4.5425 \times 10^{24})\, e^{\frac{-1.42}{0.017235}}$

$= 1.7759 \times 10^{12}$

$n_i = \sqrt{1.7759 \times 10^{12}} = 1.3326 \times 10^{6}\ \frac{\#}{m^3} = 1.3326\ \frac{\#}{cm^3}$

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

$= 2(0.017235) = 0.034469$ eV

$N_C = 8.37534 \times 10^{19} (400)^{3/2}$

$N_C = 6.7003 \times 10^{23}$ #/m^3 $= 6.7003 \times 10^{17}$ #/cm^3

$N_V = 1.60602 \times 10^{21} (400)^{3/2}$

$N_V = 1.2848 \times 10^{25}$ #/m^3 $= 1.2848 \times 10^{19}$ #/cm^3

$n_i^2 = 6.7003 \times 10^{23} (1.2848 \times 10^{25}) e^{\frac{-1.42}{0.034469}}$

$= 1.1059 \times 10^{31}$

$n_i = 3.3255 \times 10^{15}$ #/m^3 $= 3.3255 \times 10^{9}$ #/cm^3

600K $K_B T = 3(2.27613 \times 10^{-21}) = 8.2839 \times 10^{-21}$ J

$= 3(0.017235) = 0.051704$ eV

$N_C = 8.37534 \times 10^{19} (600)^{3/2}$

$N_C = 1.2309 \times 10^{24}$ #/m^3 $= 1.2309 \times 10^{18}$ #/cm^3

$N_V = 1.60602 \times 10^{21} (600)^{3/2}$

$N_V = 2.3604 \times 10^{25}$ #/m^3 $= 2.3604 \times 10^{19}$ #/cm^3

$n_i^2 = (1.2309 \times 10^{24})(2.3604 \times 10^{25}) e^{-\frac{1.42}{0.051704}}$

$= 3.4335 \times 10^{37}$

$n_i = 5.8596 \times 10^{18}$ #/m^3 $= 5.8596 \times 10^{12}$ #/cm^3