Assignment 2: Intrinsic semiconductors

1. What fraction of current in intrinsic Si ($E_g = 1.12eV$) is carried by holes? Take $\mu_e = 1350\ cm^2V^{-1}s^{-1}$ and $\mu_h = 450\ cm^2V^{-1}s^{-1}$.

2. A pure semiconductor has a band gap of $1.25\ eV$. The effective masses are $m_e^* = 0.1m_e$ and $m_h^* = 0.5m_e$, where m_e is the free electron mass. The carrier scattering time is temperature-dependent, of the form $\tau = \frac{10^{-10}}{T}\ sec$, where T is in K. Find the following at 77 K and 300 K
    (a) Concentration of electrons and holes
    (b) Fermi energy
    (c) Electron and hole mobilities
    (d) Electrical conductivity

3. GaAs is a direct band gap semiconductor with $E_g = 1.42\ eV$ at 300 K. Take $N_c = N_v = 5 \times 10^{18}\ cm^{-3}$ and independent of temperature. Calculate the intrinsic carrier concentration at room temperature. Explain numerically how the carrier concentration can be doubled without adding dopants.

4. Calculate the intrinsic carrier concentration of Ge at room temperature. Take $m_e^* = 0.56m_e$ and $m_h^* = 0.40m_e$, where m_e is the electron mass. Use this to calculate room temperature resistivity. Take $\mu_e = 3900\ cm^2V^{-1}s^{-1}$ and $\mu_h = 1900\ cm^2V^{-1}s^{-1}$. Also, calculate the position of the Fermi level at room temperature. Band gap of Ge is $0.66\ eV$.

5. In a particular semiconductor, the effective density of states are given by $N_c = N_{c0}(T)^{3/2}$ and $N_v = N_{v0}(T)^{3/2}$, where N_{c0} and N_{v0} are temperature independent. The experimentally determined intrinsic carrier concentrations as a function of temperature are tabulated below

$T(K)$	n_i (cm^{-3})
200	1.82×10^2
300	5.83×10^7
400	3.74×10^{10}
500	1.94×10^{12}

Determine the product $N_{c0}N_{v0}$ and the band gap of the semiconductor. Assume Eg is independent of temperature.