Exercise 1

Derive expression (B).

Exercise 2

Derive the expression (D).

Exercise 3

For a two band model of silicon, the band gap is 1.11 eV. Taking the effective masses of electrons and holes as $m_e = 1.08m_0$ and $m_h = 0.81m_0$, calculate the intrinsic carrier concentration in silicon at 300 K.

(Ans. 1.2×10^{16} m $^{-3}$.)

Exercise 4

Show that, if the effective masses of electrons and holes are not equal, the position of the Fermi energy for an intrinsic semiconductor is given by

$$E_F = \frac{E_c + E_v}{2} + \frac{3}{4}kT \ln \frac{m_e}{m_h}$$

Exercise 5

A sample of an intrinsic semiconductor has a band gap of 0.7 eV, assumed independent of temperature.

Taking $\mu_h = 0.5\mu_e$ and $m_h = 2m_e$, find the relationship between the conductivity at 200 K and 300 K.

(Ans. ratio of conductivity = 2014.6, $E_F(300K) - E_F(200K) = 4.33 \times 10^{-3}$ eV)

Exercise 6

Calculate the ionization energy of a donor impurity in Ge. The effective mass of electrons is $0.12m_0$ and the dielectric constant is 16.

(6.4 meV)

Exercise 7

In a p-type semiconductor 40% of atoms are ionized at 300 K. Find the location of the Fermi level with respect to the acceptor level. ($E_a - E_F = 0.016$ eV)

Exercise 8

A sample of Ge at 300 K is doped with $3 \times 10^{21}\ /\mathrm{m}^3$ of donor atoms and $4 \times 10^{21}\ /\mathrm{m}^3$ acceptor atoms. Find the densities of electrons and holes at 300 K.

(Ans. $n = 5.76 \times 10^{17}\ /\mathrm{m}^3$, $p = 10^{21}\ /\mathrm{m}^3$)

Exercise 9

Germanium has ionized acceptor density of 4×10^{21} /m ^{3} and donor density of 6×10^{21} /m ^{3}. Taking the band gap to be 0.67 eV, calculate the equilibrium density of majority and minority carriers at 450 K and also the Fermi energy. [Hint : Using the intrinsic concentration at 300 K, find n_i at 450 K and use the expression for n.]

(Ans. $n = 2.02 \times 10^{21}\ /\mathrm{m}^3$ $p = 9.62 \times 10^{17}\ /\mathrm{m}^3$ $E_F^n - E_F^i = 0.143$ eV)