Numerical

1. A conduction wire has a resistivity of 1.54×10^{-8} Ω-m at room temperature. There are 5.8×10^{28} conduction electrons per m^3. Calculate the mobility and relaxation time of electrons. **[Ans.** 6.997×10^{-3} m^2/V-s; 3.979×10^{-14} second]

2. A silicon wafer (intrinsic carrier concentration 1×10^{16} m^{-3}) is doped with 2×10^{22} aluminium atoms/m^3 and 1×10^{22} arsenic atoms/m^3. Determine the minority carrier concentration. Assume complete dopant ionization.

   [Ans. 1×10^{10}/m^3]

3. The electron and hole concentration in a P-type semiconductor is 10^{12}/m^3 and 10^{22}/m^3 respectively. If the mobility of electrons and holes are 0.04 and 0.06 m^2/V-s respectively, determine the conductivity of the material

   [Ans. 96 (ohm-metre)$^{-1}$]

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5. A semiconductor has the electron concentration 4×10^{12} cm^{-3} and hole concentration 7×10^{13} cm^{-3}. Is the semiconductor *n*-type or *p*-type? Also calculate the conductivity of this semiconductor. Given, electron mobility = 22,0000 cm^2 V^{-1} s^{-1} and hole mobility = 150 $cm^2V^{-1}s^{-1}$. **[*p*-type; 1.576 Sm^{-1}]**

6. Determine the number density of donor atoms which have to be added to an intrinsic germanium to produce an *n*-type semiconductor of conductivity 0.06 Sm^{-1}. Given the mobility of electron = 0.39 m^2 V^{-1} s^{-1}. Neglect the contribution of the holes to the conductivity. [96×10^{16} m^{-3}]

Numerical

4. Find the concentration of holes and electrons in an N-type silicon at 300 K if the conductivity is 0.1 $(\Omega\text{-cm})^{-1}$. Given that n_i at 300 K for silicon is $1.5 \times 10^{10}/\text{cm}^3$. μ_e at 300 K for silicon is 1,300 $\text{cm}^2/\text{V-s}$.

[**Ans.** $n = 4.8 \times 10^{14}$ electrons/cm^3, $p = 4.688 \times 10^5$ holes/cm^3]

5. Find the diffusion coefficients of holes and electrons for germanium at 300 K. The carrier mobilities in $\text{cm}^2/\text{V-s}$ at 300 K for electrons and holes are respectively 3,600 and 1,700. Density of carriers is $2.5 \times 10^{13}/\text{cm}^3$. Boltzmann constant $k = 1.38 \times 10^{-23}$ J/ K. $e = 1.602 \times 10^{-19}$ C. [**Ans.** 93 cm^2/s; 43.93 cm^2/s]

6. A 1 kΩ resistors is to be fabricated as a narrow strip of P-type silicon, 4 mm thick. If the strip is 400 μm long and 20 μm wide, what concentration of acceptor atoms is required ? Given hole mobility at room temperature as 480 $\text{cm}^2\ \text{V}^{-1}\ \text{s}^{-1}$.

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[**Ans.** $6.51 \times 10^{22}/\text{m}^3$]

7. The intrinsic resistivity of silicon at 27°C is 2.8×10^3 Ω-m. The electron and hole mobilities are 0.38 and 0.18 $\text{m}^2/\text{V-s}$ respectively. Calculate intrinsic carrier density at the given temperature. [**Ans.** $3.986 \times 10^{15}/\text{m}^3$]

8. For a given semiconductor, the effective mass of electron is $m_e = 1.2$ m and the Fermi level is 0.25 eV above the valence band. Determine the effective density of states in the conduction band and concentrations of electrons in semiconductor at (*i*) T = 300 K and (*ii*) T = 400 K.

[**Ans.** (*i*) $3.292 \times 10^{25}/\text{m}^3$; $2.084 \times 10^{21}/\text{m}^3$; (*ii*) $5.075 \times 10^{25}/\text{m}^3$; $36 \times 10^{21}/\text{m}^3$]

9. The effective mass of electron and hole are $m_e = 0.75$ m and $m_h = 0.5$ m respectively. Determine the position of the intrinsic Fermi level in germanium at (*i*) 300 K and (*ii*) 400 K. [**Ans.** -7.864×10^{-3} eV; -10.485×10^{-3} eV]

10. In an N-type semiconductor, the Fermi level is 0.3 eV below the conduction band at a room temperature of 300 K. If the temperature is increased to 400 K, determine the new position of Fermi level. [**Ans.** 0.4 eV]

11. In a P-type semiconductor, the Fermi level is 0.25 eV above the valence band at a room temperature of 300 K. Find the new position of the Fermi level at a temperature of 360 K. [**Ans.** 0.3 eV]

12. In an N-type semiconductor, the Fermi level lies 0.25 eV below the conduction band. Find the new position of Fermi level if the concentration of donor atoms is made 4 times. Assume kT = 0.026 eV. [**Ans.** 0.214 eV]

Numerical

1. A semiconductor has equal electron and hole concentration of $2 \times 10^8\ m^{-3}$. On doping with a certain impurity, the hole concentration increases to $4 \times 10^{10}\ m^{-3}$.
   (*i*) What type of semiconductor is obtained on doping?
   (*ii*) Calculate the new electron concentration of the semiconductor.
   (*iii*) How does the energy gap vary with doping? **[(*i*) *p*-type (*ii*) $10^6\ m^{-3}$ (*iii*) decreases]**

2. The number density of electrons and holes in intrinsic silicon at a given temperature is $4.94 \times 10^{10}\ cm^{-3}$. Calculate the resistivity and conductivity of the silicon. Given electron mobility = $1000\ cm^2V^{-1}s^{-1}$ and hole mobility = $100\ cm^2V^{-1}s^{-1}$. **[$9 \times 10^4\ \Omega\ cm$; $11.1 \times 10^{-6}\ Sm^{-1}$]**

3. Determine the number density of donor atoms which have to be added to an intrinsic germanium semiconductor to produce an *n*-type semiconductor of conductivity $5\Omega^{-1}\ cm^{-1}$. Given that mobility of electrons in *n*-type Ge is $3900\ cm^2V^{-1}s^{-1}$. Neglect the contribution of holes to conductivity. **[$8.01 \times 10^{15}\ cm^{-3}$]**

4. A semiconductor has the electron concentration of $8 \times 10^{13}\ cm^{-3}$ and hole concentration of $4 \times 10^{12}\ cm^{-3}$. Is the semiconductor *p*-type or *n*-type? Also calculate the resistivity of this semiconductor. Given, electron mobility = $24,000\ cm^2V^{-1}s^{-1}$ and hole mobility = $200\ cm^2\ V^{-1}s^{-1}$. **[*n*-type; $3.254 \times 10^{-2}\ \Omega m$]**