Unit 2- Semiconductors Question Bank AY-2023-2024

Short answer:

1. Describe the formation of energy bands in solids.
2. Define bands in solids and explain the valence band, the conduction band and the forbidden energy gap.
3. Differentiate solids according to energy band structure.
4. Define semiconductors. What are their characteristics properties?
5. If you are going to design high speed electronic device, which type of semiconductor (i.e. *n-type* or *p-type*) you would prefer and why?
6. Can an intrinsic semiconductor behave as an insulator at some temperature?
7. State the law of mass action for a semiconductor.

Long answer:

1. What do you mean by semiconductors? Explain the term intrinsic and extrinsic semiconductors.
2. Show that for an intrinsic semiconductor, at low temperature, Fermi level lies at the half of the energy band gap.
3. Why does the electrical conductivity of a pure semiconductor increase with a rise of temperature? Mention a device where this property is used.
4. Explain clearly the meaning of hole as referred to in a semiconductor. What is meant by an intrinsic and an extrinsic semiconductor? Is an n-type semiconductor negatively charged?
5. Define the following terms: (a) Doping, (b) Dopant, (c) Donors, (d) Acceptors, (e) mobility of a charge carrier and (f) drift velocity.
6. Discuss the properties of n-type and p-type semiconductors.
7. How does the free electron concentration increase over the intrinsic value in an n-type semiconductor? Will the hole concentration remain constant at the intrinsic value? If not, why?
8. How does the hole concentration increase over the intrinsic value in a p-type semiconductor? Will the electron concentration remain constant at its intrinsic value? If not, why?
9. At a high temperature an extrinsic semiconductor behaves like an intrinsic one. Why?
10. Prove that for a given material consisting of different regions with different carrier concentration, Fermi level will remain invariant at equilibrium.
11. What is Hall effect? Find the expression for Hall coefficient for a current carrying extrinsic semiconductor bar.
12. Discuss two applications of Hall effect.

Numerical Questions on Semiconductors

1. A *Si* sample, with intrinsic carrier concentration of 9.8×10^{15} /m^3 at *300 K*, is made *n*-type material. If the density of donor atoms is 10^{21} /m^3, determine the electron and hole densities. [*Ans.* $n_n = 10^{21}$ /m^3, $p_n = 9.6 \times 10^{10}$ /m^3]
2. For an intrinsic semiconductor with energy gap of *0.7 eV*, determine the position of the Fermi level at *300 K* if m_h^* is five times of m_e^*.
[*Ans. 0.3186 eV below the conduction band*]
3. The resistivity of a doped *Si* sample is 8.9×10^{-3} Ω-m. The Hall coefficient of the sample is found to be 3.06×10^{-4} m^3/C. Assuming a single carrier conduction, find the concentration and mobility of charge carriers.
[*Ans.* 2.04×10^{22} /m^3; 0.0344 $m^2V^{-1}s^{-1}$]
4. An electric field of *100 V/m* is applied to a sample of *n*-type semiconductor whose Hall coefficient is - 0.0125 m^3/C. Determine the current density in the sample, assuming the electron mobility to be 0.36 $m^2V^{-1}s^{-1}$. [*Ans.* 2880 A/m^2]
5. A copper strip *2 cm* wide and *1 mm* thick is placed in a magnetic field $B = 1.5$ Wb/m^2. If a current of *200 A* is set up in the strip, calculate the Hall voltage that appears across the strip. Given $R_H = 6 \times 10^{-7}$ m^3/C. [*Ans.* $V_H = 0.18$ *V*]
6. Assume Si [$E_g = 1.12$ *eV*] at room temperature (300 K) with the Fermi level located exactly in the middle of the energy band gap. Find the probability that a state located at the bottom of the conduction band is filled. [*Ans.* 4.43×10^{-10}]
7. In an *n-type* semiconductor, the Fermi level lies *0.3 eV* below the conduction band at room temperature. If the temperature is increased to *330 K*, find the position of Fermi level. [*Ans. 0.33 eV below conduction band*]
8. At *300 K* the intrinsic carrier concentration of silicon is 1.5×10^{16} m^{-3}. If the electron and the hole mobilities are *0.13* and 0.05 $m^2/V.s$, respectively, determine the intrinsic resistivity of silicon at *300 K*. [Ans. *Resistivity* = 2.314×10^3 Ω-m]
9. Calculate the potential barrier for *Ge* *p-n* junction at room temperature, if *p* and *n* regions are doped equally to the extent of *1* atom per 10^6 Ge atoms.
[Given. concentration of atoms in *Ge* crystal = 4.4×10^{28} m^{-3} and intrinsic carrier concentration $n_i = 2.4 \times 10^{19}$ m^{-3}] [Ans. *0.39 V*]