Arab Academy for Science & Technology & Maritime Transport
(AASTMT – Cairo Branch)
College of Engineering & technology
Electronics & Communication Engineering Department

Course : Solid State Electronics
Course Code : EC210

Sheet # 8

Constants:

$\varepsilon_o = 8.85 \times 10^{-12}\,\text{Fm}^{-1}$

Charge of electron $(q) = 1.6 \times 10^{-19}\,\text{C}$

Mass of electron $(m_e) = 9.1 \times 10^{-31}\,\text{kg}$

Plank's Constant $(h) = 6.63 \times 10^{-34}\,\text{Js}$

Put (T) for the true statement or (F) for the false statement giving reasons:

1. An intrinsic semiconductor behaves like an insulator at 0 K.
2. An extrinsic semiconductor has non-zero conductivity at 0 K.
3. The intrinsic carrier concentration of Si (E_g = 1.12 eV) is less than the intrinsic carrier concentration of GaAs (E_g = 1.42 eV).
4. When adding Boron (B) as impurities to Silicon (Si), an n-type material is produced.
5. Both the electrons in the conduction band and the holes in the valence band contribute to the electric current in a semiconductor.
6. At zero temperature Kelvin, the hole concentration in a p-type semiconductor is larger than the electron concentration.

Choose the correct answer justifying your choice:

1. Doping silicon with Aluminum results in …………..
   (a) n-type semiconductor (b) p-type semiconductor
   (c) intrinsic semiconductor (d) non-conducting material

2. Doping silicon with phosphorous results in …………..
   (a) n-type semiconductor (b) p-type semiconductor
   (c) intrinsic semiconductor (d) non-conducting material

3. In an intrinsic semiconductor ……………………..
   (a) There is no allowed energy levels between E_c and E_v.
   (b) There is an allowed energy level which is little above E_v.
   (c) There is an allowed energy level which is little below E_c.
   (d) There is an allowed energy level which is near the middle between E_c and E_v .
4. In an n-type semiconductor ……………………..
   (a) There is no allowed energy levels between E_c and E_v.
   (b) There is an allowed energy level which is little above E_v.
   (c) There is an allowed energy level which is little below E_c.
   (d) There is an allowed energy level which is near the middle between E_c and E_v .

5. In a p-type semiconductor ……………………..
   (a) There is no allowed energy levels between E_c and E_v.
   (b) There is an allowed energy level which is little above E_v.
   (c) There is an allowed energy level which is little below E_c.
   (d) There is an allowed energy level which is near the middle between E_c and E_v .

6. The electron and hole concentrations are equal to zero …………….
   (a) in an intrinsic semiconductor. (b) in an extrinsic semiconductor.
   (c) in a semiconductor at 0 K temperature. (d) in a semiconductor at very high temperature.

7. In an intrinsic semiconductor, if n and p are the electron and hole concentrations, …...
   (a) n must be zero (b) p must be zero
   (c) n and p must be equal (d) n and p must not be equal

8. In an n-type semiconductor, if n and p are the electron and hole concentrations, …...
   (a) n must be zero (b) p must be zero
   (c) n is smaller than p (d) n is larger than p

9. In a p-type semiconductor, if n and p are the electron and hole concentrations, …...
   (a) n must be zero (b) p must be zero
   (c) n is smaller than p (d) n is larger than p

Solve the following Problems:

[1] Find the resistivity of intrinsic Germanium (Ge) at 300K where μ_n= 3800 cm^2/V.sec, μ_p=1800 cm^2 /V.sec and n_i= 1.6*10^{13} cm^{-3}.

[2] For intrinsic silicon at room temperature, given that the intrinsic concentration is 1x10^{10} cm^{-3}, the mean time between scatterings is 2x10^{-13} sec for electrons, and1x10^{-13} sec for holes, the conductivity effective mass for electrons is 0.26m_o, and 0.386m_o for holes, where m_o is the rest mass for the electrons.
Find:
a. Electron and hole mobilities
b. Total conductivity.
c. The current density if the silicon has a length of 1μm, and an applied voltage of 10V.
d. The total current if the cross section area is 100μm^2.
Hint: use MKS system

[3] Example 5.3 p.392.

[4] An intrinsic semiconductor with L=10μm. The potential V(x) applied is given as: $\frac{-2}{10\times10^{-6}}x+2$.
Plot both V(x) and the potential energy versus x.

[5] For an electron mobility of 500 cm^2/Vsec, calculate the time between collisions, for an electric field of 100 V/cm, calculate also the distance traveled by an electron between collisions. Take m* = m in this calculation.

[6] For a p-type silicon slice doped with Boron (Acceptor, N_A). The doping gradient have a linear dependence on distance, with N_A(at x=0um) = 5x10^{16} cm^{-3}, and N_A(at x= 100um) =10^{17}cm^{-3}. Given that the cross section area = 10 um^2, length= 100um, mobility = 600 cm^{2}V^{-1}sec^{-1}, temperature = 27^{o}C, find the total diffusion current.
Note: Use k= 1.3806488×10^{-23} J.K^{-1}.