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March 2023

B.Tech. - 1 SEMESTER

Physics (Semiconductor Physics) (BSC101D)

Time : 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*

PART-A

1. (a) Write any *two* basic assumptions of the free electron theory. (1.5)

(b) Draw the energy band diagram of a metal-semiconductor contact. (1.5)

(c) Define extrinsic semiconductor along with two examples. (1.5)

(d) If a metallic material is cooled through its melting temperature at an extremely rapid rate, it will form a

non-crystalline solid (i.e., a metallic glass). Will the electrical conductivity of the non-crystalline metal be greater or less than its crystalline counterpart? Why? (1.5)

(e) Will Zn act as a donor or acceptor when added to the compound semiconductor GaAs? Why? (Assume that Zn is a substitutional impurity). (1.5)

(f) Give *one* practical example each of quantum wells, wires, and dots. (1.5)

(g) What are direct and indirect semiconductors? Is silicon a direct or indirect semiconductor? (1.5)

(h) What is Fermi's Golden rule? (1.5)

(i) Write *three* uses of solar cell. (1.5)

(j) Explain the effect of impurity on photoconductivity. (1.5)

PART-B

2. (a) Explain why the carrier mobility in group II-VI semiconductors is lower than that in group III-V and IV semiconductors. (5)

(b) Argue why the concept of mobility is meaningless for an electron moving in a vacuum. (5)

(c) How does Fermi energy vary with temperature? Explain. (5)

3. (a) Define the terms absorption, spontaneous emission and stimulated emission in reference to light-semiconductor interaction. (5)

(b) Why does the electrical conductivity increase when certain solids are exposed to light of suitable wavelengths? Suggest simple model of a photo-conductor and explain the following :
(i) Gain (ii) Effect of traps. (10)

4. (a) When is a metal-semiconductor contact called an ohmic contact? Explain the most widely used method to make ohmic contacts to semiconductors. Is there any other type of metal-semiconductor contact? If yes, name it. (10)

(b) For intrinsic gallium arsenide, the room-temperature electrical conductivity is 10^{-6} (Ohm m)$^{-1}$. The electron and hole mobilities are, respectively, 0.85 and 0.04 m^2/V-s. Compute the intrinsic carrier concentration at room temperature. (5)

5. (a) Write a short note on "density of available electron states". (5)

(b) What do you mean by intrinsic semiconductor? Obtain an expression for the intrinsic carrier concentration in an intrinsic semiconductor. Under what conditions will Fermi level be in the middle of the forbidden gap? (10)

6. (a) The following data are known for copper :

Density = 8.92×10^3 kg/m^3, Resistivity = 1.73×10^{-8} Ohm-m, Atomic weight = 63.5. Calculate the mobility and average time of collision of the electrons in copper. (5)

(b) Explain the experimental setup for the hot point probe method for conductivity measurement with the help of neat diagram. (10)

7. (a) Explain Van der Pauw measurements for carrier density, resistivity and Hall mobility. (8)

(b) Define band gap. Describe a simple method to determine band gap with the help of UV-Vis spectrometer. Make a schematic diagram too. (7)