Roll No: ..... Total Pages : 3

300104

December, 2019

B.TECH. (CE/CSE/IT) - Ist SEMESTER

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) What is drift velocity? (1.5)

(b) Explain the concept of hole as a consequence of effective mass. (1.5)

(c) Why a semiconductor acts as an insulator at absolute zero? (1.5)

(d) Assuming there are 5×10^{28} atoms/m^3 in copper, determine the Hall Coefficient. (1.5)

(f) Differentiate between diffusion and drift mechanism for flow of electrons. (1.5)

(g) What do you mean by knee voltage when PN junction diode is in forward bias? (1.5)

(h) In 100 nsec a pulse of 8×10^6 photons of wavelength 1300 nm falls on a photo detector. On an average 6.4×10^6 electron hole pairs are generated. What is the quantum efficiency of photo detector? (1.5)

(i) What do you understand by optoelectronic devices? Give *two* examples. (1.5)

(j) Explain the structure of buckyballs. (1.5)

PART-B

2. (a) What is the effect of periodic potential on the energy of electrons in a metal? Explain it on the basis of Kronig-Penney model and explain the formation of energy bands. (10)

(b) Define effective mass. Prove that it is dependent on energy and wave vector. (5)

3. (a) Draw the energy band diagram of a metal semiconductor junction and label the important quantities such as Fermi level, band bending, etc. (7)

(b) For intrinsic semiconductor with a gap width of 1 eV calculate the position of Fermi level at T = 0° K and at T = 300° K if $m^*_h = 6\ m^*_e$ where m^*_h and m^*_e are effective masses of hole and electrons respectively. Boltzmann constant $k = 1.4 \times 10^{-16}$ ergs/0°K. (8)

4. (a) Explain four probe methods. Derive an equation to calculate resistivity of a thin semiconductor. (7)

(b) Distinguish between metals, semiconductors and insulators using band theory. (8)

5. (a) Explain photovoltaic effect. With required diagrams discuss construction and working of solar cell. (5)

(b) What is radiative and non-radiative transition? Explain in brief the optical joint density of states. (10)

6. (a) Define following terms with respect to Light-semiconductor devices. (i) Absorption of radiation. (ii) Spontaneous emission (iii) Stimulated emission (iv) Meta stable state. (10)

(b) Discuss UV-VIS method for band gap measurement of semiconductors. (5)

Roll No. .....

Total Pages : 3

300212

May, 2019

B.Tech. (CE/CSE/IT) II SEMESTER

PHYSICS (SEMICONDUCTOR PHYSICS) - BSC-101-D

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) Define density of states. (1.5)

(b) What is direct and indirect bandgaps? (1.5)

(c) Define Intrinsic and Extrinsic semiconductor. (1.5)

(d) What is hole? How it is created? (1.5)

(e) Define spontaneous emission and stimulated emission. (1.5)

(f) What is joint density of states? (1.5)

(g) Define Hall mobility and Hall coefficient. (1.5)

(h) To calculate the probability that an energy state above E_F occupied by an electron at T = 300 K. Determine the probability that an energy level 3 kT above the Fermi energy is occupied by an electron. (1.5)

(i) Define quantum wells, wires and dots. (1.5)

(j) What is fabrication? (1.5)

PART–B

2. (a) Explain Kroning–Penny model to introduce origin of band gap. (10)

(b) Prove that for Kroing–Penny potential with $p << 1$, the lowest energy band at $k = 0$ is

$$E = \hbar^2 p/ma^2$$

(5)

3. (a) What are transition rates? Explain Fermi's golden rule. (10)

(b) Write short notes on photovoltaic effect. (5)

4. Explain distribution of electrons and holes in pure semiconductor and obtained the n_o and p_o equation. (15)

5. (a) What is the Van der Pauw method? How carrier density, resistivity and Hall mobility measured by this method? (10)

(b) Explain Hot -point probe measurement. (5)

6. (a) What is Heterojunction solar cell? Explain Heterojuctions and associated band-diagrams. (10)

(b) Explain (qualitatively) density of states in 1d, 2D and 0D. (5)

7. Write short notes on the following :

(a) Metal-semiconductor junction.

(b) Absorption /transmission measurement.

(c) Drude model. (15)

Roll No. 1201500476

Total Pages : 3

300104

Dec., 2018

B.Tech. (CE/CSE/IT) Ist Semester

SEMICONDUCTOR PHYSICS

(BSC101D)

Time : 3 Hours]

[Max. Marks : 75

Instructions :

(i) It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.

(ii) Answer any four questions from Part-B in detail.

(iii) Different sub-parts of a question are to be attempted adjacent to each other.

PART–A

1. (a) What do you mean by donor and acceptor impurity? (1.5)

(b) Draw E-k diagram for a semiconductor using Kronig Penney model. (1.5)

(c) Define ohmic contacts. (1.5)

(d) What does Fermi level in band gap mean? (1.5)

(e) Which type of semiconductor has direct bandgap? Give one example. (1.5)

(f) Define exciton. (1.5)

(g) What is the basic principle of UV visible spectroscopy? (1.5)

(h) Differentiate between hetero-junction and homo-junction. (1.5)

(i) Give one example each of 1D, 2D and 3D nano-material. (1.5)

(j) Define stimulated emission. (1.5)

PART–B

2. (a) Show, with the help of Kronig Penney model, that band gap exists in the case of semiconductors. Also explain the concept of effective mass. (10)

(b) Define Fermi level. Show that it lies midway in the bandgap in intrinsic semiconductors. (5)

3. (a) Define the terms drift velocity and diffusion velocity. When p-n junction is forward biased which one is dominant and why? (5)

(b) What do you mean by an intrinsic semiconductor? Obtain an expression for the carrier concentration in an intrinsic semiconductor. (10)

4. Explain in detail one method to calculate the band gap experimentally. (15)

5. (a) Draw the characteristics of PN junction diode in forward and reverse biased conditions and also define the knee voltage. (10)

(b) Explain how the energy band gap of semiconductor material can be calculated using UV-Vis spectroscopy. (5)

6. (a) Compare a Schottky diode to a PN-diode. In which applications do Schottky diodes perform better than PN-diodes? (5)

(b) What do you mean by low dimensional structure? Classify the different type of low dimensional structure. (10)

7. (a) Draw the Fermi function at three temperatures lower, moderate and high. (5)

(b) Write the assumptions of Drude model and calculate the equation of conductivity using this model. (10)

Roll No. ..... Total Pages : 4

004101

April 2022

B.Tech. (CSE/IT) - I SEMESTER

Physics (Semiconductor Physics) (BSC-101D)

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) What are the limitations of free electron theory? (1.5)

(b) What is the change in the shape of E-k curve when potential barrier strength is zero? (1.5)

(c) What do you understand by the term band gap? (1.5)

(d) Prove that for intrinsic semiconductor Fermi energy level lies midway to the bandgap. (1.5)

(e) Give *two* examples of each direct and indirect bandgap semiconductors. (1.5)

(f) Differentiate between diffusion and drift mechanism for flow of electrons. (1.5)

(g) What do you mean by knee voltage when PN junction diode is in forward bias? (1.5)

(h) In 100 nsec a pulse of 8×10^6 photons of wavelength 1300 nm falls on a photo detector. On an average 6.4×10^6 electron hole pairs are generated. What is the quantum efficiency of photo detector? (1.5)

(i) What do you understand by optoelectronic devices? Give *two* examples. (1.5)

(j) Explain the structure of buckyballs. (1.5)

PART-B

2. (a) What is the effect of periodic potential on the energy of electrons in a metal? Explain it on the basis of Kronig-Penney model and explain the formation of energy bands. (10)

(b) Define effective mass. Prove that it is dependent on energy and wave vector. (5)

3. (a) Draw the energy band diagram of a metal semiconductor junction and label the important quantities such as Fermi level, band bending, etc. (7)

(b) For intrinsic semiconductor with a gap width of 1 eV calculate the position of Fermi level at T = 0° K and at T = 300° K if $m^*_h = 6\ m^*_e$ where m^*_h and m^*_e are effective masses of hole and electrons respectively. Boltzmann constant $k = 1.4 \times 10^{-16}$ ergs/0°K. (8)

4. (a) Explain four probe methods. Derive an equation to calculate resistivity of a thin semiconductor. (7)

(b) Distinguish between metals, semiconductors and insulators using band theory. (8)

5. (a) Explain photovoltaic effect. With required diagrams discuss construction and working of solar cell. (5)

(b) What is radiative and non-radiative transition? Explain in brief the optical joint density of states. (10)

6. (a) Define following terms with respect to Light-semiconductor devices. (i) Absorption of radiation. (ii) Spontaneous emission (iii) Stimulated emission (iv) Meta stable state. (10)

(b) Discuss UV-VIS method for band gap measurement of semiconductors. (5)

What do you mean by Density of state? Give its physical significance. Compare the density of state function for zero-, one- and two-dimensional system. (15)

Roll No. ..... Total Pages : 4

018101

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)

August/September 2022

B.Tech.- II SEMESTER

B.Tech(CSE(AIML)/CE/CE(DS)/CSE/IT/CE(DS)/CSE)

Physics (Semiconductor Physics) (BSC-101D/BSCH-101D)

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.*
4. *The candidate is required to attempt the question paper in the language as per his/her medium of instructions.*

PART -A

Q1 (a) What are the basic assumptions of classical free electron theory? (1.5)

(b) Explain density of state. Write its applications. (1.5)

(c) Distinguish Direct and indirect bandgaps semiconductors. (1.5)

(d) What is Fermi level and Fermi energy? (1.5)

(e) What is meant by effective mass of electron? (1.5)

(f) What is hall mobility? (1.5)

(g) Explain the Quantum wells, wires, and dots. (1.5)

(h) Define Photovoltaic effect and write its applications. (1.5)

(i) Distinguish Ohmic and Schottky contacts. (1.5)

(j) What is the physical significance of E-K diagram? (1.5)

PART -B

Q2 (a) Derive an expression for density of energy states. Obtain an expression for Fermi energy in metals at T = 0 K. (10)

(b) In a solid, consider the energy level lying 0.01 eV below Fermi level. What is the probability of this level not being occupied by an electron? (5)

Q3 (a) Explain formation of energy bands in solids on the basis of band theory of solids. (5)

(b) Write any two techniques of synthesis and characterization of quantum dots. (10)

Q4 Define energy level and energy band. Explain with proper diagrams, how on the basis of band theory, solids are classified as conductors, insulators and semiconductors. (15)

Q5 (a) How to measure the band gap of a semiconductor through UV-Vis spectroscopy? (5)

(b) Explain the 'Kronig-Penny' model of solids and show that it leads to energy band structure of solids. (10)

Q6 (a) Draw the Density of states curve for 2D, 1d and 0D dimensions and also give examples of 2D, 1d and 0D structures. (10)

(b) Find the temperature at which there is 1% probability that a state with energy 2 eV is occupied. Given that Fermi energy is 1.5 eV. (5)

Q7 Explain in details the Four-point probe and vander Pauw methos to measure the resistivity of semiconductor materials with formulas and diagrams. Also write the merits and demerits of both methods. (15)

****