Roll No. .....

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 : 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

$$E = \hbar^2 p/ma^2 \quad (5)$$

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)

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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)

(e) What is reverse saturation current? (1.5)

(f) What is Vander Pauw method for resistivity? (1.5)

(g) What is the use of UV-Vis spectra in semiconductor? (1.5)

(h) Explain 0-d structure giving example. (1.5)

(i) Why is stimulated emission necessary for stimulated emission? (1.5)

(j) What is static resistance of a diode? (1.5)

PART-B

2. (a) What are the assumptions of Drude model? Derive the expression for conductivity of metals using this model. (10)

   (b) What are Brillouin zones? Illustrate by constructing two Brillouin zones for square lattice. (5)

3. (a) Discuss Kronig Penney model and show how it explains the forbidden bands. (10)

   (b) Explain Schottky junction. (5)

4. (a) Define hot point probe measurement. Derive an expression for finding the carrier concentration for a p-type semiconductor. (10)

   (b) A He-Ne laser emits light of wavelength 6328 Å at 300 K. Calculate the ratio of population of two states. (5)

5. (a) Derive an expression for carrier concentration in extrinsic semiconductors. What would be the position of Fermi level? Explain. (10)

   (b) State any *four* applications of Hall Effect. (5)

6. (a) If F(E) = 0.2 at 300 K and Fermi energy of a metal is 3.2 eV, find the energy at 300 K. (5)

   (b) What are low dimensional structures? Classify different types of low dimensional structures. (10)

7. Write short notes: (5×3)

   (a) Absorption spectroscopy.

   (b) Photo voltaic effect.

   (c) n-n heterojunction.

Sr. No.300209

Oct. 2020

B.TECH (CE/CSE/IT) II 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

Q1 (a) What is the difference between drift and diffusion? (1.5)

(b) State Bloch's theorem for a periodic function. (1.5)

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

(d) The threshold wavelength of a photo diode is 750 nm. Calculate the energy gap in the photo diode in electron volts. (1.5)

(e) What do you mean by negative effective mass of an electron? (1.5)

(f) Briefly explain: "Contact resistance becomes significant for semiconductors". (1.5)

(g) What do you understand by Joint density of states? (1.5)

(h) Explain 1-d structure giving example. (1.5)

(i) What are photovoltaic devices? (1.5)

(j) List various parameters which can be extracted from I -V curve for a diode. (1.5)

PART-B

Q2 (a) Obtain an expression for thermal conductivity of a metal on the basis of free electron theory. (5)

Q2 (b) For what voltage will the reverse current in a p-n junction germanium diode attain a value of 90% of its saturation value at room temperature? (4)
(Given Boltzmann constant $k=1.3807 \times 10^{-23}$ J K^{-1})

Q2 (c) Explain the origin of capacitance in a p-n junction. Briefly explain the parameters which can be determined from the capacitance measurement of a p-n junction. (6)

Q3 (a) What is the effect of periodic potential on the energy of electrons in a metal? Explain it on the basis of Kronig Penny model and explain the formation of energy bands. (8)

Q3 (b) Discuss, with the help of a proper diagram, the measurement of carrier density, resistivity and hall mobility by Van der Pauw method. (7)

Q4 (a) How can you measure band-gap by UV-Vis Spectroscopy? (5)

(b) Explain the difference in recombination process in direct and indirect band gap semiconductors. And explain its effect on the charge carrier life time and luminescent properties for a semiconductor. (10)

Q5 (a) Derive an expression for carrier concentration in extrinsic semiconductors. What would be the position of Fermi level? Explain. (10)

Q5 (b) Differentiate between Ohmic contact and Schottky junction for metal-semiconductor junction. (5)

Q6 (a) If F(E)=0.2 at 300K and Fermi energy of a metal is 3.2eV, find the energy at 300K. (5)

Q6 (b) What are low dimensional structures? Classify different types of low dimensional structures. (5)

Q6 (c) Briefly explain one method for determination of sign of charge carrier in a semiconductor. (5)

Q7 Write short notes: (5x3)

(a) Deep-level transient spectroscopy (DLTS)
(b) Semiconductor materials for Optoelectronics
(c) n-n heterojunction

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Sr. No: 018201

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)

7. 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)

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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)

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)

for metals – $\sigma \propto 1/T$ $\rho \propto T$

for semiconductors – $\sigma \propto T$

$\mu = \frac{v_d}{E}$ →

Roll No. 2101500413 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)

Page :
Date :

Q.

II-VI Semiconductors

Zn (30) O (8)

Cd (48) S (16)

} lower carrier mobility

(III-V)

(13) Al P, S

(31) Ga As (33)

(GaAs)

} Higher carrier mobility why?

used in heterostructures, used to Mobility enhancement

Q.4(b)

$\sigma_i = 10^{-6}\ (\Omega m)^{-1}$

$\mu_e = 0.85$

$\mu_h = 0.04\ m^2/V_s$

$n_i = ?$ $T = 300K$

$\sigma_i = e(n_e\mu_e + n_h\mu_h)$

$n_e = n_h = n_i$

$\sigma_i = e n_i (\mu_e + \mu_h)$

$10^{-6} = 1.6\times10^{-19} \times n_i (0.85 + 0.04)$

$10^{-6} = 1.6\times10^{-19} \times n_i \times 0.89$

$n_i = \frac{10^{-6}\times10^{22}}{1.6\times10^{19}\times0.89}$

$n_i = \frac{10^{16}}{16\times89}$

$n_i = \frac{10000\times10^{12}}{1424}$

$n_i = 7.0\times10^{12}$

(b) Explain the experimental setup for the hot point probe method for conductivity measurement with the help of neat diagram. (7)

7. Write short notes :

(a) Deep-level transient spectroscopy (DLTS).

(b) n-n heterojunction.

(c) UV-VIS method. (15)

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

018202

July 2023

B.Tech. - II 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) 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. (1.5)

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

(c) Define occupation probability. (1.5)

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

(e) Differentiate between 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 parameters which can be extracted from I-V curve for a diode? (1.5)

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

PART–B

2. (a) Discuss the motion of electrons in a periodic field of a crystal and show that effective mass of an electron in a crystal is inversely proportional to the second derivative of E-k curve. (10)

(b) Using band theory of solids, distinguish between metals, semiconductors and insulators. (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 gap width of 0.7 eV, determine the density of holes and electrons at 300 K. (8)

4. (a) Discuss, with the help of a proper diagram, the measurement of carrier density, resistivity and hall mobility by Van der Pauw method. (7)

(b) 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. (8)

5. (a) Explain photovoltaic effect. With required diagrams discuss the 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. (8)

(b) Explain the experimental setup for the hot point probe method for conductivity measurement with the help of neat diagram. (7)

7. Write short notes :

(a) Deep-level transient spectroscopy (DLTS).

(b) n-n heterojunction.

(c) UV-VIS method. (15)

Roll No. 23012011006

Total Pages : 3

018101

December 2023

B.Tech. 1st 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) Discuss E-K diagram for free electron and under periodic potential. (1.5)

(b) Define effective mass. How it varies at the boundary of Brillouin zone? (1.5)

(c) Differentiate between Intrinsic and extrinsic semiconductors. (1.5)

(d) What is Schottky Junction? Give some example. (1.5)

(e) What is exciton? How it is formed? (1.5)

(f) Explain the term absorption, spontaneous and stimulated emission. (1.5)

(g) What are the advantages for using Four probe methods? (1.5)

(h) How DLTS can be used for detection of electrical active defect? (1.5)

(i) Draw the density of state of 2D, ID and 0D nanomaterials. (1.5)

(j) What are the different approaches for the fabrication of nanomaterials? (1.5)

PART–B

2. (a) Discuss the origin of band gap by Kronig-Penny Model (10)

(b) Differentiate between direct and indirect band gap. (5)

3. (a) Define density of state. How these vary with energy in case of extrinsic semiconductor? (5)

(b) Derive an expression for concentration of charge carrier in extrinsic semiconductor. How Fermi level varies with temperature? (10)

4. (a) What do you mean by Optical Joint density of state? Derive an expression for it. (10)

(b) What is Photovoltaic effect? Discuss its applications. (5)

5. (a) How the band gap of a material can be determined using UV-Vis spectroscopy? (5)

(b) Explain in detail the difference between Four-point probe and van der Pauw measurements for measurement of resistivity of semiconductor. (10)

6. (a) How I-V measurement can be carried out? How activation energy for conduction can be determined by I-V measurements. (10)

(b) What are Quantum Dots? Discuss the method of synthesis of it. (5)

7. Discuss the Principle and working of Scanning Electron Microscope. (15)