Roll No. ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐   Total No. of Pages : 02

Total No. of Questions : 18

B.Tech. (CSE/IT) (2018 & Onwards)/(CE)/(ME)   (Sem.–1,2)
SEMI-CONDUCTOR PHYSICS
Subject Code : BTPH-104-18
M.Code : 75360

Time : 3 Hrs.   Max. Marks : 60

INSTRUCTIONS TO CANDIDATES :
 1. SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.
 2. SECTION - B & C. have FOUR questions each.
 3. Attempt any FIVE questions from SECTION B & C carrying EIGHT marks each.
 4. Select atleast TWO questions from SECTION - B & C.

SECTION-A

Write briefly :

1.   What are the basic assumptions of free electron gas model?

2.   What is the origin of the energy gap?

3.   What do you mean by occupation probability?

4.   What is the basic difference between metal and semiconductor?

5.   What do you mean by optoelectronic devices?

6.   What do you mean by spatial coherence?

7.   Write a short note on Photovoltaic effect.

8.   What do you mean by density of states for phonons?

9.   What do you understand by resistivity?

10. Write a short note on divergence.

11.   What do you mean by Fermi energy? Obtain an expression for the Fermi energy of a free electron gas in three dimensions.

12.   Explain the periodicity character of the potential in crystals. State and prove Bloch theorem in this reference.

13.   What is the difference between intrinsic and extrinsic semiconductors? Discuss in detail the dependence of Fermi level on carrier concentration and temperature.

14.   a)   What do you mean by metal-semiconductor junction? Discuss in detail Schottky metal-semiconductor junction.

       b)   Explain the mechanism of diffusion and drift in detail.

SECTION-C

15.   a)   Discuss stimulated emission, absorption, and spontaneous emission in detail.

       b)   Derive the Einstein coefficients describing the probabilities of stimulated absorption and stimulated emission.

16.   a)   What is population inversion? How is it achieved?

       b)   Write a note on Fermi's golden rule.

17.   a)   Discuss van der Pauw method for resistivity measurement in detail.

       b)   Discuss Hot-point probe measurement method.

18.   a)   Write a note on capacitance-voltage measurements.

       b)   How can we extract different parameters from I-V characteristics of diode?

NOTE : Disclosure of Identity by writing Mobile No. or Making of passing request on any page of Answer Sheet will lead to UMC against the Student.

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B.Tech. Only for CSE/IT (2018 Batch)   (Sem.–1)
SEMI-CONDUCTOR PHYSICS
Subject Code : BTPH-104-18
Paper ID : [75360]

Time : 3 Hrs.   **Max. Marks : 60**

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SECTION-A

Write briefly :

1. Draw the density of states, $g(E)$ vs E diagram for 2-D and 3-D systems.

2. Differentiate between metals, semiconductors and insulators. Also draw the band diagrams for each.

3. Briefly explain : "*For LED applications we need direct band gap materials*".

4. Briefly explain : "*Semiconductors have higher mobility as compared with metals*".

5. List 4 direct bandgap semiconductors and their main applications.

6. What are photovoltaic devices?

7. List main features of Kronig-Penny model.

8. What is Hall effect?

9. Briefly explain : "*Contact resistance becomes significant for semiconductors*".

10. Draw the schematic for the hot-point probe measurement and briefly explain its basic principle.

SECTION-B

11. Explain in detail (with diagrams) the origin of the bandgap in solids using the Bloch's theorem for particles in periodic potential. (8)

12. Determine the value of Fermi temperature, Fermi velocity, Fermi momentum and electrical conductivity for Sodium (Fermi energy, $E_F = 3.1$ eV, Electron density, n= 2.5×10^{28}/m^3, mobility, $\mu = 5.8 \times 10^{-3}$ m^2/Vs). (e = 1.6×10^{-19} C, electron mass, m = 9.1×10^{-31} kg, 1 eV = 1.6×10^{-19} J Boltzmann constant, k = 1.3808×10^{-23} J/K) (8)

13. Explain (with diagrams) the origin of depletion region and built in potential for a p-n junction diode. Give the expressions for the built-in potential and depletion region width. Also sketch the variation of the electric field and charge density across the barrier region.
(8)

14. a) 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.

    b) Differentiate between ohmic contact and schottky junction for metal- semiconductor junction. (5 + 3)

SECTION-C

15. a) Explain (using suitable diagrams) various possible absorption transitions in a semiconductor.

    b) List and briefly explain salient features of a semiconductor laser. (4 + 4)

16. a) Write short notes on :

    i) Phonon density of states

    ii) Excitons

    b) Briefly explain the concept of population inversion and its significance for lasers.
    ($3 \times 2 + 2$)

17. a) List and briefly explain (with suitable diagram) one method for determination of :

    i) Resistivity for a semiconductor.

    ii) Sign of charge carrier in a semiconductor.

    b) List various parameters which can be extracted from l-V curve for a diode. ($3 \times 2 + 2$)

18. a) 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.

    b) Compare van der Paw method with 4-probe method for resistivity measurement.(5 + 3)

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SECTION-A

Write briefly :   [2×10=20]

1. What do you understand by free electron gas model of metals?

2. Discuss the physical significance of the wave function ψ.

3. State Bloch's theorem for a periodic system.

4. How n-type and p-type semiconductors are produced?

5. What do you mean by negative effective mass of electron?

6. The threshold wavelength of a photo diode is 750 nm. Calculate the energy gap in the photo diode in electron volts.

7. Explain the term absorption and spontaneous emission of radiation.

8. Why four probes are required for the measurement of resistivity of semiconductor in four probe method?

9. What do you mean by effective mass of electron?

10. What physical parameters can be known from I-V characteristics of diode?

SECTION-B

11. Obtain an expression for thermal conductivity of a metal on the basis of free electron theory. [8]

12. 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]

13. Derive an expression for the densities of electrons and holes in the conduction and valence bands respectively of an intrinsic semiconductor. [8]

14. a) Distinguish between intrinsic and extrinsic semiconductors with suitable examples. [4]

    b) Differentiate metals, semiconductors and insulators on the basis of band theory. [4]

SECTION-C

15. What do you mean by population inversion? Obtain a relation between transition probabilities of spontaneous and stimulated emission. [3+5=8]

16. How does a semiconductor laser differ from other laser? Explain main features of the semiconductor laser and its applications. [8]

17. What physical parameters can be measured form capacitance-voltage measurements? Describe a method for the measurement of divergence and wavelength of light. [3+5=8]

18. Discuss with proper diagram about the measurement of carrier density, resistivity and hall mobility by van der Pauw method. [8]

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