APPLIED PHYSICS

UNIT – I

Lasers & Holography

1. Write the characteristics laser. Explain the terms (i) spontaneous emission, (ii) stimulated emission, (iii) pumping, (iv) population inversion and (v) lasing action.
2. Obtaine the relation between Einstien's coefficients and show that $N_2>N_1$ for laser action.
3. Describe the construction and working of He-Ne laser with neat diagrams.
4. (i) Describe the construction and working of semiconductor laser with neat diagrams.
   (ii) Write any four applications of lasers
5. (i) Explain the construction and re-construction of a hologram.
   (ii) Explain the basic principle of holograph and mention some applications of holography.

Fibre Optics

6. What is the basic principle of fibre optics? Explain the propagation of light through an optical fibre and derive the expressions for numerical aperture and acceptance angle.
7. Explain the fibre drawing by double crucible method. Write some applications of optical fibres.
8. What is pulse dispersion? Obtain an expression for total time delay due to intermodal dispersion in a step-index optical fibre.
9. Explain the types of optical fibres.

UNIT – II

Wave Mechanics

10. Explain the physical significance of wave function Ψ. Derive Shrödinger time dependent and time independent wave equations.
11. Apply Schrödinger time-independent wave function to obtain an expression for wave function and energy values of a particle in an infinite square well potential.
12. What is a potential barrier? How does a particle with the energy lower than the barrier height tunnel through it? Give one example.

Band Theory of Solids

13. Write the salient features of Kronig-Penney model and explain how it leads to the concept of formation of bands in solids.
14. Discuss the classification of solids based on the band theory of solids.

UNIT – III

Elements of Statistical Mechanics

15. Explain Maxwell-Boltzmann statistics and derive an expression for its distribution function.
16. Explain Bose-Einstein statistics and derive an expression for its distribution function.
17. Explain Fermi-Dirac statistics and derive an expression for its distribution function. Distinguish among M-B, B-E and F-D statistics.
18. What is photon gas? Derive Planck's black body radiation formula and deduce Wein's and Rayleigh-Jeans' laws from Planck's law.
19. Write short notes on the following:
    i. Electron gas

ii. Fermi energy level

UNIT – IV

Semiconductors

20. What are intrinsic and extrinsic semiconductors? Explain the nature of Fermi level in intrinsic and extrinsic semiconductors.
21. Derive the expressions for carrier concentration and energy gap for an intrinsic semiconductor.
22. What is Hall effect? Describe the experiment to determine Hall coefficient of a material.
23. Explain the construction and working of solar cell.

Superconductors

24. Explain the general properties of superconductors and also mention some applications of superconductors.
25. Explain B.C.S. theory of superconductivity.
26. Discuss the types of superconductors with neat diagrams.
27. What is Meissner's effect? Show that a superconductor is a perfect diamagnetic.

UNIT – V

Nanomaterials

28. What are top-down and bottom-up methods? Explain the preparation of nanomaterials by ball milling method.
29. Explain the preparation of nanomaterials by sol-gel method.
30. Discuss surface-to-volume ratio and quantum confinement in nanomaterials. Mention some important applications of nanomaterials.
31. Write short notes on the following:
    i. Properties of materials at reduced size
    ii. Carbon nanotubes.

Techniques for Characterization of Materials

32. Explain how X-ray fluorescence and Auger process are helpful in characterizing the materials.
33. Explain the construction and working of scanning electron microscope (SEM) with a neat diagram.
34. Explain the construction and working of tunneling electron microscope (TEM) with a neat sketch.
35. Explain the construction and working of atomic force microscope (AFM) with a neat sketch.

UNIT – I

Fibre Optics

1. Determine the numerical aperture and acceptance angle of a step-index optical fibre whose core and cladding have refractive indices 1.5 and 1.48 respectively. If the optical

fibre is kept in water (μ = 1.33), find numerical aperture and acceptance angle. (A: 0.244, 14.13º & 0.183, 10.54º)

2. Numerical aperture of a fibre is 0.5 and core refractive index is 1.48. Find the refractive index of cladding also find the acceptance angle of the fibre cable immersed in water of refractive index of 1.33. (A: 1.39 & 22.08º)
3. A step-index fibre with a core of refractive index 1.55 and cladding of refractive index 1.51. Compute the intermodal dispersion per km of length of the fibre and the total dispersion in a 15 km length of the fibre. (A: 138 ns/km, 2.07 µs)

UNIT – II

Wave Mechanics

4. Calculate the permitted energy levels of an electron confined in a box of width 1 Å. (Ans: 37 eV, 148 eV, 333 eV, …….).
5. A particle lies within a box of 10 Å width with the least energy. Find the probability of finding the particle within 1 Å interval at the center of the box. (A: 0.2)
6. A particle is moving in a one-dimensional box of infinite height. What is the probability of finding the particle in a small interval Δx at the center of the box when it is in the energy state, next to least energy state? (A: 0)
7. A particle is in one dimensional infinite potential well of width 0.2×10^{-9} m. It is found that when the energy of the particle is 230 eV, its eigen function has 5 antinodes. Find the mass of the particle and show that it can never have the energy equal to 1 keV. (Ans: 9.3×10^{-31} kg)
8. Calculate the energy difference between the ground and first excite states for an elctron in 1-D rigid box of length 1 Å. (Ans: 112.5 eV)
9. Can you observe the energy states of a ball of mass 10 g moving in a box of length 10 cm? (Ans: No)
10. An electron is confined to move between two rigid walls separated by 10^{-9} m. Find the de Broglie wavelength representing the first three allowed energy sates of the electron and corresponding energies. (Ans: 20 Å, 10 Å, 6.67 Å & 0.38 eV, 1.52 eV, 3.42 eV)

UNIT – II

11. Find the number of ways of arranging 6 electrons in 10 states. (Ans: 210)

UNIT – IV

Semiconductors

12. The intrinsic carrier density at 300 K in silicon is 1.5×10^{16} m^{-3}. If the electron and hole mobilities are 0.13 and 0.05 $m^2V^{-1}s^{-1}$ respectively, calculate the conductivity of intrinsic silicon. (Ans: 4.32×10^{-4} Sm^{-1})
13. For an intrinsic semiconductor having energy band gap 0.7 eV, calculate the density of holes and electrons at 27°C. (Ans: 3.6×10^{19} m^{-3})
14. For the intrinsic semiconductor with energy gap of 0.7 eV, determine the position of Fermi level at 300 K if $m_p^* = 6m_e^*$. (Ans: 0.385 eV from top of VB)
15. The Hall coefficient of a semiconductor is 3.22×10^{-4} m^3/C. Its resistivity is 9×10^{-3} Ω-m. Find the mobility and the carrier concentration. (0.0357 $m^2V^{-1}s^{-1}$ & 1.94×10^{22} m^{-3})
16. The resistivity of a sample is 9 mΩ-m and its holes have mobility of 0.03 $m^2V^{-1}s^{-1}$. Calculate Hall coefficient. (2.7×10^{-4} m^3/C)
17. The resistivity of a doped silicon material is 9×10^{-3} Ωm. The Hall coefficient is 3.6 ×

10^{-4} m^3/C. Assuming single carrier concentration, find mobility and the density of charge carrier. (Ans: 0.04 m^2/V-s, 1.73625 × 10^{22} /m^3)

18. An n-type semiconductor specimen has Hall coefficient is 3.66 × 10^{-11} m^3/C. The conductivity of the specimen is found to be 112 × 10^7 $\Omega^{-1}m^{-1}$. Calculate the charge carrier density and electron mobility. (Ans: 1.7 × 10^{29} m^{-3}, 0.4092 m^2/V-s)
19. Show that Fermi level in an intrinsic semiconductor lies midway in the forbidden band.

Superconductors

20. The superconducting transition temperature of lead is 7.26 K. The critical field at 0 K is 64 × 10^3 A/m. Find the critical field at 5 K. (Ans: 33.64 × 10^3 A/m)
21. The critical field for Nb is 1 × 10^5 A/m at 8 K and 2 × 10^5 A/m at 0 K. Calculate the transition temperature and the critical current at 8 K if the diameter of Nb wire is 1 mm. (Ans: 11.31 K & 314.2 A)
22. Calculate the critical current density for 1 mm diameter wire of lead at 4.2 K. Given that T_C = 7.18 K and H_0 = 6.5× 104 A/m. (Ans: 17.16 × 107 A/m^2)
23. The transition temperature of mercury of atomic weight of 199.5 is 4.185 K. What is the transition temperature of mercury of atomic weight of 203.4? (Ans: 4.144 K)
24. Prove that a superconductor is a perfect diamagnet.