18182

BRAINWARE UNIVERSITY

Term End Examination 2025-2026

Programme – B.Tech.(CSE)-AIML-2024/B.Tech.(CSE)-DS-2024/B.Tech.(CSE)-CYS-2024/B.Tech.(CSE)-AIML-2025/B.Tech.(CSE)-CYS-2025/B.Tech.(CSE)-DS-2025

Course Name – Semiconductor Physics

Course Code - BBS00015

(Semester I)

Full Marks : 60 **Time : 2:30 Hours**

[The figure in the margin indicates full marks. Candidates are required to give their answers in their own words as far as practicable.]

Group-A

(Multiple Choice Type Question) 1 x 15=15

1. *Choose the correct alternative from the following :*

(i) Identify the total energy operator.

a) $-i\hbar\frac{\partial}{\partial t}$ b) $i\hbar\frac{\partial}{\partial t}$

c) $-\hbar\frac{\partial}{\partial t}$ d) $\hbar\frac{\partial}{\partial t}$

(ii) Choose the correct probability of occupation at Fermi level at any non-zero temperature.

a) 0% b) 100%
c) 50% d) 25%

(iii) At 0 K temperature, semiconductors are ________.

a) perfect metals b) perfect non-metals
c) perfect insulators d) perfect superconductors

(iv) Select the correct microscopic form of Ohm's law.

a) $J = \sigma E$ b) $J = \sigma E/m$
c) $J = m/\sigma E$ d) $J = \sigma/E$

(v) In p-type semiconductors, hole concentration is ________ electron concentration.

a) equal to b) greater than
c) less than d) half of

(vi) Silicon is not suitable for fabrication of light emitting diodes because it is ________.

a) a direct band gap semiconductor b) a wide bandgap semiconductor
c) a narrow band gap semiconductor d) an indirect bandgap semiconductor

(vii) Which principle is responsible for the propagation of light in an optical fiber?

a) scattering
b) dispersion
c) total internal reflection
d) polarization

(viii) For a particular material, the Hall coefficient is found to be zero. The material is ________.

a) intrinsic semiconductor
b) extrinsic semiconductor
c) metal
d) insulator

(ix) Which one of the following breakdowns occurs in highly doped diodes?

a) Zener
b) Avalanche
c) Both a and b
d) No breakdown occurs

(x) Which type of laser uses a mixture of gases as the active medium?

a) Solid-state laser
b) Semiconductor laser
c) He-Ne laser
d) Dye laser

(xi) In hot-point probe measurement of a semiconductor sample, if the hot side is negative then the sample is ________ type.

a) p
b) n
c) p-n junction
d) intrinsic

(xii) Dual nature of matter was proposed by ________.

a) Einstein
b) Planck
c) Boltzmann
d) de Broglie

(xiii) The modulus squared of a wavefunction, $|\psi|^2$, represents the ________ of finding a particle at a specific location in space.

a) probability
b) probability density
c) uncertainty
d) none of these

(xiv) The energy of a particle moving in a one-dimensional potential box is ________ the mass of the particle.

a) independent of
b) directly proportional to
c) inversely proportional to
d) none of these

(xv) The average distance travelled by free electrons in a metal between two successive collisions is known as ________.

a) drift velocity
b) mobility
c) mean free time
d) mean free path

Group-B

(Short Answer Type Questions) 3 x 5=15

2. Distinguish between direct and indirect bandgap semiconductors. (3)

3. Determine the occupational probability of electrons at an energy level $E = E_F - k_BT$. (3)

4. A typical He-Ne laser radiates at wavelength $\lambda = 632.8$ nm. How many photons per second would be emitted by a 1 mW He-Ne laser? (3)

5. Determine whether the function $\psi(x) = e^{ikx}$ is an eigenfunction of the operator d^2/dx^2. If so, find the corresponding eigenvalue. (3)

6. An n-type semiconductor has an impurity level 25 meV below the conduction band. Estimate the temperature of the semiconductor if an amount of energy equal to k_BT is given to the extra electron of the impurity ion such that it can jump to the conduction band. (3)

OR

The electron and hole mobilities in a Si sample are 0.135 and 0.048 $m^2 V^{-1} s^{-1}$, respectively. Calculate the conductivity of intrinsic Si at 300 K if the intrinsic carrier concentration is 1.5×10^{16} m^{-3}. (3)

Group-C

(Long Answer Type Questions) 5 x 6=30

7. In a Hall coefficient experiment, a current of 0.25 A is sent through a metal strip of thickness 0.2 mm. The Hall voltage across the strip is found to be 0.15 mV when a magnetic field of 2000 gauss is applied. Calculate the carrier concentration in the metal. (5)

8. Describe stopping potential and work function in the context of photoelectric effect. Light of wavelength 500 nm falls on a metal of work function 1.6 eV. Calculate the stopping potential. (5)

9. State and explain Heisenberg's uncertainty principle. Calculate the minimum uncertainty in the position of an electron moving with speed 2.5×10^4 m/s. (5)

10. How does the resistivity ρ of a semiconductor vary with temperature T? Write the exponential relationship involving ρ, T, and bandgap E_g. In an experiment, the resistivity of a silicon sample is measured as a function of temperature. Given that the slope of the ln ρ vs $1/T$ graph is 6500 K, estimate its bandgap. (5)

11. The core of an optical fiber has a refractive index of 1.56, and the critical angle at the core-cladding interface is 75°. Calculate the numerical aperture and acceptance angle of the fiber. If a light ray enters at 30° with the fiber axis, will it propagate through the fiber? (5)

12. Describe the Wiedemann-Franz law. Using this law, calculate the thermal conductivity of a metal having an electrical resistivity of 3.25×10^{-8} Ω m at 300 K. The Lorentz number of the metal is 2.15×10^{-8} W Ω K^{-2}. (5)

OR

Define the terms: current density, drift velocity, and mobility. Starting from the microscopic form of Ohm's law and the relation between current density and drift velocity, derive the expression: $\sigma = ne\mu$ (symbols have their usual meanings). (5)

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