BRAINWARE UNIVERSITY

Term End Examination 2024-2025

Programme – B.Tech.(CSE)-AIML-2021/B.Tech.(CSE)-DS-2021/B.Tech.(CSE)-AIML-2022/B.Tech.(CSE)-AIML-2023/B.Tech.(CSE)-DS-2023/B.Tech.(CSE)-AIML-2024/B.Tech.(CSE)-DS-2024/B.Tech.(CSE)-CYS-2024

Course Name – Semi-Conductor Physics/Semiconductor Physics

Course Code - BSCM101/BSCD101/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) Which pair of observables of a particle cannot be measured precisely at the same time?

a) Spin and color
b) Energy and torque
c) Position and momentum
d) Size and speed

(ii) Which of the following functions is the eigenfunction of the operator d/dx?

a) $\sec(x)$
b) $\tan(x)$
c) $\ln(x)$
d) e^{-x}

(iii) The quantum mechanical operator for the momentum of a particle moving in one dimension is ____.

a) $i\hbar\frac{d}{dx}$
b) $-i\hbar\frac{d}{dx}$
c) $i\hbar\frac{d}{dt}$
d) $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$

(iv) In the photoelectric effect, the stopping potential refers to ____.

a) the energy required to remove an electron from the sample
b) the photon energy
c) the minimum electric potential that causes the photocurrent to vanish
d) the kinetic energy of the ejected photoelectron

(v) The resistivity of a conductor depends on _____.

a) length of the conductor
b) area of cross-section of the conductor

c) temperature
d) mass of the material

(vi) What is the correct form of Wiedemann-Franz law?

a) $\frac{\sigma_T}{\sigma} = LT$
b) $\frac{\sigma}{\sigma_T} = LT$
c) $\frac{\sigma_T}{\sigma} = \frac{L}{T}$
d) $\frac{\sigma}{\sigma_T} = \frac{T}{L}$

(vii) What happens to the free electrons when an electric field is applied?

a) They move randomly and collide with each other.
b) They move in the direction of the field.
c) They remain stable.
d) They move in the direction opposite to that of the field.

(viii) Identify the correct statement regarding the influence of temperature on conductivity.

a) Conductivity of metals increases with increase in temperature.
b) Conductivity of metals decreases with increase in temperature.
c) Conductivity of semiconductors decreases with increase in temperature.
d) Conductivity of semiconductors does not change with increase in temperature.

(ix) What should be the correct valency of the impurity to form an acceptor?

a) 3
b) 6
c) 5
d) 4

(x) The leakage current across a *p-n* junction is due to the _____.

a) junction capacitance
b) majority carriers
c) ions
d) minority carriers

(xi) In p-type semiconductors, hole concentration is _____ electron concentration.

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

(xii) In a ruby laser, population inversion is achieved by _____.

a) optical pumping
b) inelastic atom-atom collision
c) chemical reaction
d) applying strong electric field

(xiii) The core of an optical fiber has a _____.

a) lower refractive index than that of the air
b) lower refractive index than that of the cladding
c) higher refractive index than that of the cladding
d) similar refractive index to that of the cladding

(xiv) The merit of the four-point probe method for determining resistivity is that _____.

a) it gives the resistivity at a localized region of the sample
b) it injects excess minority carriers
c) it needs very small current
d) it gives the average resistivity of the sample

(xv) What is the unit of current density?

a) Kelvin
b) Volts
c) A/m^2
d) Henry

Group-B

(Short Answer Type Questions) 3 x 5=15

2. Calculate the minimum uncertainty in the position of an electron moving with a speed of 3×10^6 m/s. (3)

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

4. Calculate the numerical aperture and acceptance angle of an optical fiber if the refractive indices of its core and cladding are 1.562 and 1.497, respectively. (3)

5. The operating temperature of the filament of a vacuum tube is around 1050 K. At what wavelength will it radiate maximum? (3)

6. Estimate the diffusion coefficient of electron in Si at 300 K if $\mu_e = 0.19\ m^2\ V^{-1}\ s^{-1}$. (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 $1.5 \times 10^{16}\ m^{-3}$. (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 the terms current density and drift velocity. Show that the magnitude of the current density of electrons in a conductor can be written as $j = -nev_d$. (5)

9. The operator $\left(x + \frac{d}{dx}\right)$ has eigenvalue α. Determine the corresponding eigenfunction. (5)

10. A three-level laser emits laser light at a wavelength of 550 nm. In the absence of optical pumping, at what temperature will the equilibrium ratio of the population of the upper level to that of the lower level be equal to 1/2? (5)

11. A uniform gold wire has a resistivity of $2.44 \times 10^{-8}\ \Omega$ m at room temperature. For an electric field of 2 V/cm along the wire, calculate the magnitude of average drift velocity of electrons assuming there are 5.9×10^{28} conduction electrons per m^3. Estimate the value of the mobility of the electrons. (5)

12. A light of wavelength 3000 Å falls on a metal surface of work function 2.28 eV. Calculate the maximum speed of the ejected photoelectrons. (5)

OR

Write down Schrödinger's equation for a free particle in a one-dimensional potential box. Applying appropriate boundary conditions, determine the wave function of the particle. (5)

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