BRAINWARE UNIVERSITY

Term End Examination 2024-2025

Programme – B.Tech.(CSE)-2024/B.Tech.(CSE)-AIR-2024/B.Tech.(EE)-2024

Course Name – Semiconductor Physics

Course Code - BBS00015

(Semester II)

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) The total probability of finding a particle anywhere in the space must be _____.

a) one
b) any real number
c) zero
d) a complex number

(ii) The electron mobility is given by _____.

a) v_d/E
b) v_d/m
c) v_d/T
d) T/E

(iii) Materials having bandgap more than 5 eV is termed as _____.

a) superconductors
b) insulators
c) semiconductors
d) conductors

(iv) Select the correct assumption of free electron theory from the followings.

a) Electrons can move freely only at the centre of the solid.
b) Electrons can move freely only at the top surface of the solid.
c) Electrons can move freely through the entire solid.
d) Electrons can move freely only along the surfaces of the solid.

(v) Identify the correct example of an acceptor in the context of a semiconductor.

a) Boron
b) Phosphorus
c) Copper
d) Glass

(vi) Fermi energy level for *p*-type extrinsic semiconductors lies _____.

a) closer to valence band
b) closer to conduction band
c) at middle of the band gap
d) closer to donor level

(vii) What is the wavelength of the output of a He-Ne laser?

a) 632.8 nm
b) 600 nm
c) 532.8 nm
d) 500 nm

(viii) Four-point probe method is used to measure _____.

a) capacitance b) inductance
c) resistivity d) Hall coefficient

(ix) In an optical fiber, total internal reflection occurs at the _____.

a) core-cladding interface b) air-core interface
c) cladding-jacket interface d) none of these

(x) According to the band theory of solids, free electron moves in a _____ potential of lattice.

a) periodic b) constant
c) zero d) exponential

(xi) What is the primary function of a Zener diode in an electronic circuit?

a) Rectification of AC-signals b) Amplification of signals
c) Regulation of voltage d) Generation of high-frequency signals

(xii) The energy of a photon is _____ to its wavelength.

a) equal b) directly proportional
c) inversely proportional d) not related

(xiii) If a quantum particle is in a potential well, its energy levels are _____.

a) continuous b) discrete
c) infinite d) random

(xiv) Which of the following functions is NOT an eigenfunction of the operator d^2/dx^2?

a) e^x b) $\ln x$
c) $\sin x$ d) $\cos x$

(xv) In the Hall effect, a positive Hall coefficient signifies that the majority charge carriers are _____.

a) electrons b) holes
c) both electrons and holes d) none of these

Group-B

(Short Answer Type Questions) 3 x 5=15

2. Estimate the de Broglie wavelength associated with an electron accelerated through a potential difference of 120 V. (3)

3. A n-type semiconductor has a donor level below the conduction band. At 300 K, all donor electrons are excited to the conduction band. Given that the conduction band is at 1.2 eV relative to the valence band, estimate the donor level energy relative to the valence band. (3)

4. Compare a laser with an ordinary light source. (3)

5. Distinguish between n-type and p-type semiconductors. (3)

6. Calculate the relaxation time of conduction electrons in a metal of resistivity $1.2 \times 10^{-4}\ \Omega$ m and electron concentration $4.8 \times 10^{28}\ m^{-3}$. (3)

OR

The energy near the valence band edge of a crystal is given by $E = -Ak^2$, where $A = 10^{-39}$ J m^2. Estimate the effective mass of the electron. (3)

Group-C
(Long Answer Type Questions) 5 x 6=30

7. State the Wien's displacement law. If light from the Sun is found to have a maximum intensity near the wavelength of 500 nm, estimate the temperature of the surface of the Sun. (5)

8. Write the expression for the Fermi-Dirac distribution $f(E)$ and explain each term. Draw a graph of $f(E)$ as a function of the energy E at temperature $T = 0$ K. Calculate the occupation probability at the Fermi energy ($T \neq 0$). (5)

9. Evaluate the numerical aperture, acceptance angle and critical angle of an optical fiber having core and cladding refractive indices 1.5 and 1.45, respectively. (5)

10. Determine the resistivity and resistance of an intrinsic silicon sample of length 20 mm and cross-sectional area 3 mm^2 at room temperature. The intrinsic carrier density of silicon at room temperature is 1.5×10^{16} m^{-3}, and the mobilities of electrons and holes are 0.15 m^2 V^{-1} s^{-1} and 0.05 m^2 V^{-1} s^{-1}, respectively. (5)

11. The Hall coefficient of a certain silicon specimen is measured to be -7.35×10^{-5} m^3 C^{-1}. If the conductivity of the specimen is 200 Ω^{-1} m^{-1}, calculate the concentration and mobility of the charge carriers. (5)

12. Write down Planck's formula for blackbody radiation and describe each term. Deduce Wien's distribution from Planck's formula in the short-wavelength ($\lambda \to 0$) limit. (5)

OR

Calculate the energy values (in eV) of the first three energy levels of an electron trapped in an infinite quantum well of width 0.6 nm. (5)

.....