# BRAINWARE UNIVERSITY

## Term End Examination 2022

## Programme – B.Tech.(CSE)-AIML-2021/B.Tech.(CSE)-DS-2021/B.Tech.(CSE)-AIML-2022

## Course Name – Semi-Conductor Physics

## Course Code - BSCM101/BSCD101

## ( 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) With forward bias to a pn junction, the width of depletion layer

a) decreases
b) increases
c) remains the same
d) at first increases, then decreases

(ii) Considering the mass-action law in semiconductor, which of the following is the correct option at the thermal equilibrium. (Symbols have their usual meaning)

a) n/p= constant
b) $np = n_i^2$
c) $n > {n_i^2}/{p}$
d) $n < {n_i^2}/{p}$

(iii) For the semiconductors with an indirect bandgap identify the correct statement from the following.

a) Materials for which minimum of valence band and maximum of conduction band do not occur at same value of $k$
c) Materials for which maximum of valence band and minimum of conduction band occurs at same value of $k$
d) Materials for which maximum of valence band and minimum of conduction band do not occur at same value of $k$

(iv) With the increase of temperature, an extrinsic semiconductor behaves as

a) conductor
b) insulator
c) intrinsic semiconductor
d) superconductor

(v) Which of the following is not an assumption in Drude-Lorentz theory of free electrons?

a) Metals contain free electrons that move through a lattice of positive ions
b) Electric field produced by lattice ions is considered to be uniform throughout the solid and hence neglected
c) Free electrons in a metal resemble
d) The electrons are distributed among the

molecules of a gas and therefore the laws of kinetic theory of gases are applicable to free electrons

energy levels according to Pauli's exclusion principle

(vi) The resistivity of a material depends on which of the following factors:

a) length of the conductor
b) area of cross section of the conductor
c) temperature
d) mass of the material

(vii) Express Wiedemann-Franz law in a correct form as

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

(viii) In Relativistic case, as the velocity of the particle approaches the speed of light, the predicted Kinetic energy will approach

a) zero
b) non-relativistic kinetic energy
c) rest mass energy
d) Infinite

(ix) Population inversion in preparing laser beam can be achieved

a) when one of the excited states is less populated than the ground state
b) when one of the excited states is more populated than the ground state
c) when the population of one excited state and the ground state are equal
d) on the basis of none of the above conditions

(x) The shape of E-K diagram of the conduction band and valance band is predicted to be

a) horizontal
b) vertical
c) circle
d) parabolic

(xi) No two electrons will have all the four quantum numbers equal. This statement is proposed as

a) Uncertainty principle
b) Pauli exclusion principle
c) Hund's rule
d) Aufbau's principle

(xii) At 0 K temperature, semiconductors are

a) Perfect metals
b) Perfect non-metals
c) Perfect insulator
d) Perfect conductor

(xiii) 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) $\hbar\frac{\partial}{\partial t}$

(xiv) Merit of four point probe method of 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) Identify the correct relation between total energy [E] and temperature [T] in Stefan-Boltzmann law

a) $E \propto T^4$
b) $E \propto T^{-4}$
c) $E \propto T$
d) $E \propto T^{-1}$

## Group-B

(Short Answer Type Questions) 3 x 5=15

2. Construct the expression of the effective mass of electron based on the Kronig-Penny Model. (3)

3. Explain the terms acceptance angle and numerical aperture in connection to an optical fiber. (3)

4. Describe the physical interpretation of wave function in quantum mechanics. (3)

5. Solve the normalization constant $a$ if the wave function has the following form (3)

$$\psi(x) = a \sin\frac{\pi x}{L}, \quad \text{for } 0 \le x \le L$$

$$= 0, \quad \text{otherwise}$$



**OR**

Write down the differences between avalanche and Zener breakdown. (3)

6. Distinguish between direct and indirect band gap semiconductors. (3)

**OR**

Evaluate the de-Broglie wavelength of an electron moving with velocity 0.6c. [hint: use relativistic corrections] (3)

## Group-C

(Long Answer Type Questions) 5 x 6=30

7. What do you mean by meta-stable state? Explain the working principle of laser. (5)

8. Explain attenuation in optical fibre by illustrating different mechanism responsible for it. (5)

9. Deduce Stefan's law from Planck's radiation formula. (5)

10. Write down Schrödinger's equation for one-dimensional motion for a free particle in a one-dimensional potential box. Appling appropriate boundary conditions calculate its eigen energies. (5)

11. Compare the assumptions of classical free-electron theory (Drude-Lorentz theory) and quantum free electron theory. (5)

**OR**

The E-k relationship for electrons in a hypothetical energy band is given by, $E(k) = E_0 [1 - \exp(-2a^2k^2)]$, where a is lattice constant. Calculate the effective mass at k=0. (5)

12. Justify that the sum of the probability of occupancy of an energy state at $\Delta E$ above the Fermi level and that at $\Delta E$ below the Fermi level is unity. (5)

OR

The electrons are allowed to pass through a crystal with lattice constant 0.1 nm. Estimate the uncertainty in its velocity. (5)



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