

MODULE–1: QUANTUM MECHANICS

Q1. The de Broglie wavelength of a particle is given by

- A) $\lambda = hE$
- B) $\lambda = h/p$
- C) $\lambda = p/h$
- D) $\lambda = h/m$

Answer: B

Reason: De Broglie hypothesis states that matter waves have wavelength $\lambda = h/p$, where p is momentum.

Q2. Heisenberg's uncertainty principle relates uncertainty in

- A) Position and force
- B) Energy and mass
- C) Position and momentum
- D) Velocity and acceleration

Answer: C

Reason: The principle states $\Delta x \cdot \Delta p \geq \hbar/2$, linking position and momentum.

Q3. The physical significance of the wave function ψ is that

- A) ψ represents probability
- B) ψ^2 represents probability density
- C) ψ represents energy
- D) ψ represents momentum

Answer: B

Reason: According to Born interpretation, $|\psi|^2$ gives probability density.

Q4. For a particle in a one-dimensional infinite potential well, the energy levels are

- A) Continuous
- B) Negative
- C) Quantized
- D) Zero

Answer: C

Reason: Boundary conditions lead to discrete (quantized) energy eigenvalues.

MODULE–2: ELECTRICAL PROPERTIES OF MATERIALS

Q5. The main failure of classical free electron theory is its inability to explain

- A) Electrical conductivity
- B) Ohm's law
- C) Specific heat of metals
- D) Drift velocity

Answer: C

Reason: Classical theory predicts much higher specific heat than experimentally observed.

Q6. Matthiessen's rule is related to

- A) Band gap variation
- B) Total resistivity
- C) Hall voltage
- D) Carrier mobility

Answer: B

Reason: It states that total resistivity is the sum of temperature-dependent and impurity resistivity.

Q7. Fermi energy is defined as

- A) Maximum energy of electrons at 0 K
- B) Average energy of electrons
- C) Minimum energy level
- D) Energy gap

Answer: A

Reason: At absolute zero, electrons fill states up to the Fermi energy.

Q8. In an intrinsic semiconductor, the Fermi level lies

- A) Near conduction band
- B) Near valence band
- C) At mid-gap
- D) Outside the band gap

Answer: C

Reason: Equal number of electrons and holes places the Fermi level at the middle of the band gap.

MODULE-3: SUPERCONDUCTIVITY

Q9. Zero electrical resistance in superconductors occurs below

- A) Room temperature
- B) Debye temperature
- C) Critical temperature
- D) Melting point

Answer: C

Reason: Superconductivity appears only below the critical temperature (T_c).

Q10. The Meissner effect refers to

- A) Zero resistance
- B) Expulsion of magnetic field
- C) Flux quantization
- D) Persistent current

Answer: B

Reason: Superconductors expel magnetic flux when cooled below T_c .

Q11. Cooper pairs are formed due to interaction between electrons and

- A) Magnons
- B) Photons
- C) Phonons
- D) Ions

Answer: C

Reason: Lattice vibrations (phonons) mediate electron pairing.

Q12. Type-II superconductors allow magnetic field penetration in the form of

- A) Domains
- B) Layers
- C) Vortices
- D) Currents

Answer: C

Reason: Magnetic flux penetrates as quantized vortices between lower and upper critical fields.

MODULE-4: PHOTONICS

Q13. Einstein's A coefficient represents

- A) Absorption
- B) Stimulated emission
- C) Spontaneous emission
- D) Scattering

Answer: C

Reason: A coefficient corresponds to spontaneous emission probability.

Q14. Population inversion is necessary for

- A) LED operation
- B) Laser action
- C) Optical fiber transmission
- D) Photodetection

Answer: B

Reason: Laser action requires more atoms in excited state than ground state.

Q15. Numerical aperture of an optical fiber indicates

- A) Fiber length
- B) Acceptance angle
- C) Core diameter
- D) Attenuation

Answer: B

Reason: Numerical aperture determines light-gathering ability and acceptance angle.

Q16. Mach–Zehnder interferometer works on the principle of

- A) Diffraction
- B) Polarization
- C) Interference
- D) Reflection

Answer: C

Reason: It splits and recombines beams to produce interference.

MODULE–5: QUANTUM COMPUTING

Q17. A qubit differs from a classical bit because it can exist in

- A) 0 only
- B) 1 only
- C) Superposition
- D) Integer states

Answer: C

Reason: Qubits can exist in a linear combination of $|0\rangle$ and $|1\rangle$ states.

Q18. The Bloch sphere is used to represent

- A) Classical bits
- B) Quantum gates
- C) Qubit states
- D) Measurement outcomes

Answer: C

Reason: Any single-qubit state can be visualized on the Bloch sphere.

Q19. Which quantum gate creates equal superposition from $|0\rangle$ state?

- A) Pauli-X
- B) Pauli-Z
- C) Hadamard
- D) CNOT

Answer: C

Reason: Hadamard gate transforms $|0\rangle$ to $(|0\rangle+|1\rangle)/\sqrt{2}$.

Q20. Entanglement is a phenomenon where

- A) Qubits act independently
- B) Measurement outcomes are correlated
- C) States are classical
- D) Energy is conserved

Answer: B

Reason: Entangled qubits show strong correlations irrespective of distance.

MODULE–1: QUANTUM MECHANICS (Additional)

Q21. The principle of complementarity was proposed by

- A) Einstein
- B) Bohr
- C) Schrödinger
- D) Heisenberg

Answer: B

Reason: Niels Bohr introduced complementarity to explain wave–particle duality.

Q22. The Schrödinger wave equation is

- A) Classical
- B) Relativistic
- C) Deterministic
- D) Linear and wave-based

Answer: D

Reason: Schrödinger equation is linear and governs wave behavior of particles.

Q23. Eigenvalues of an operator correspond to

- A) Allowed measurements
- B) Wave packets
- C) Probability densities
- D) Boundary conditions

Answer: A

Reason: Measurement results are eigenvalues of the corresponding operator.

Q24. Expectation value represents

- A) Most probable value
- B) Average value
- C) Maximum value
- D) Minimum value

Answer: B

Reason: Expectation value gives the statistical average of measurements.

Q25. Quantum tunneling occurs because of

- A) High velocity
- B) Finite potential barrier
- C) Zero energy
- D) Classical motion

Answer: B

Reason: Finite barriers allow wave penetration even if $E < V$.

MODULE–2: ELECTRICAL PROPERTIES (Additional)

Q26. Density of states depends on

- A) Temperature only
- B) Energy
- C) Electric field
- D) Magnetic field

Answer: B

Reason: DOS specifies number of states available per energy interval.

Q27. Fermi–Dirac distribution function gives

- A) Number of electrons
- B) Energy gap
- C) Probability of occupancy
- D) Conductivity

Answer: C

Reason: It gives probability that an energy state is occupied by an electron.

Q28. At absolute zero, Fermi–Dirac distribution becomes

- A) Gaussian
- B) Linear
- C) Step function
- D) Exponential

Answer: C

Reason: All states below E_F are occupied and above are empty.

Q29. Hall effect is used to determine

- A) Band gap
- B) Type of semiconductor
- C) Fermi energy
- D) Refractive index

Answer: B

Reason: Hall coefficient sign indicates n-type or p-type material.

Q30. Extrinsic semiconductors are formed by

- A) Heating
- B) Alloying
- C) Doping
- D) Cooling

Answer: C

Reason: Controlled impurity addition modifies electrical properties.

MODULE–3: SUPERCONDUCTIVITY (Additional)

Q31. Persistent current means

- A) Alternating current
- B) Infinite resistance
- C) Zero decay current
- D) High voltage

Answer: C

Reason: Superconducting current flows indefinitely without decay.

Q32. Critical magnetic field is the field above which

- A) Resistance decreases
- B) Superconductivity is destroyed
- C) Current increases
- D) Flux quantizes

Answer: B

Reason: Above critical field, superconducting state collapses.

Q33. Silsbee effect is related to

- A) Critical current
- B) Critical temperature
- C) Flux quantization
- D) Josephson effect

Answer: A

Reason: High current produces magnetic field destroying superconductivity.

Q34. Two-fluid model assumes superconductors contain

- A) Only electrons
- B) Normal electrons only
- C) Super electrons and normal electrons
- D) Ions only

Answer: C

Reason: It models coexistence of superconducting and normal carriers.

Q35. Flux quantization unit is

- A) h/e
- B) $h/2e$
- C) e/h
- D) $2h/e$

Answer: B

Reason: Flux is quantized in units of $h/2e$ due to Cooper pairs.

MODULE–4: PHOTONICS (Additional)

Q36. Stimulated emission requires

- A) Population inversion
- B) Thermal equilibrium
- C) High temperature
- D) Low pressure

Answer: A

Reason: More atoms must be in excited state than ground state.

Q37. Optical modulators are used to

- A) Detect light
- B) Generate light
- C) Control light properties
- D) Store light

Answer: C

Reason: Modulators control intensity, phase, or polarization.

Q38. Pockels effect occurs in

- A) All materials
- B) Centrosymmetric crystals
- C) Non-centrosymmetric crystals
- D) Metals

Answer: C

Reason: Linear electro-optic effect exists only in non-centrosymmetric crystals.

Q39. Kerr effect is

- A) Linear electro-optic effect
- B) Magnetic effect
- C) Nonlinear electro-optic effect
- D) Thermal effect

Answer: C

Reason: Kerr effect varies refractive index quadratically with electric field.

Q40. V-number of an optical fiber decides

- A) Fiber length
- B) Core diameter
- C) Number of modes
- D) Losses

Answer: C

Reason: V-number determines whether fiber is single or multimode.

MODULE-5: QUANTUM COMPUTING (Additional)

Q41. Dirac notation $|\psi\rangle$ represents

- A) Scalar
- B) Bra vector
- C) Ket vector
- D) Operator

Answer: C

Reason: $|\psi\rangle$ denotes a state vector (ket).

Q42. Pauli-X gate is equivalent to

- A) NOT gate
- B) AND gate
- C) OR gate
- D) Identity gate

Answer: A

Reason: Pauli-X flips $|0\rangle$ to $|1\rangle$ and vice versa.

Q43. CNOT gate operates on

- A) One qubit
- B) Three qubits
- C) Two qubits
- D) Four qubits

Answer: C

Reason: It uses one control and one target qubit.

Q44. Bell states are examples of

- A) Classical states
- B) Mixed states
- C) Product states
- D) Entangled states

Answer: D

Reason: Bell states show maximum quantum entanglement.

Q45. Measurement of a qubit causes

- A) Superposition
- B) Entanglement
- C) Collapse of wave function
- D) Gate operation

Answer: C

Reason: Measurement collapses qubit to a definite state.

MIXED / CONCEPTUAL (Additional)

Q46. Moore's law predicts

- A) Constant chip size
- B) Doubling of transistors
- C) Reduction in power
- D) Increase in cost

Answer: B

Reason: It states transistor count doubles approximately every two years.

Q47. Anharmonicity in superconducting qubits is needed to

- A) Increase noise
- B) Distinguish energy levels
- C) Reduce coherence
- D) Increase temperature

Answer: B

Reason: It prevents equal spacing of energy levels.

Q48. Single Photon Avalanche Diode works in

- A) Forward bias
- B) Zero bias
- C) Reverse bias above breakdown
- D) AC mode

Answer: C

Reason: Operates in Geiger mode for single-photon detection.

Q49. Superconducting nanowire detectors rely on

- A) Heating effect
- B) Photon-induced resistance
- C) Hall effect
- D) Tunneling

Answer: B

Reason: Photon absorption creates a resistive hotspot.

Q50. Quantum advantage refers to

- A) Lower power usage
- B) Smaller circuits
- C) Faster solution for specific problems
- D) Cheaper computers

Answer: C

Reason: Quantum computers outperform classical ones for certain tasks.