MODULE WISE QUESTION BANK

Module-1 Quantum Mechanics

2 Marks Questions

1. What are matter waves? Give the expression for de Broglie wavelength.
2. State Heisenberg's Uncertainty principle. Give the expression for uncertainty in measurement of position and momentum.
3. Give the physical significance of Heisenberg uncertainty principle.
4. Mention any two properties of wave function.
5. What is normalization of wave function, give its mathematical representation.
6. What are eigen values and Eigen functions?
7. Mention the expression for time independent Schrondinger's wave equation for a particle in one dimensional potential well.
8. Define zero-point energy with mathematical representation.

5 Marks Questions

1. State and explain de-Broglie's hypothesis.
2. Write a short note on wave function.
3. Derive an expression for de Broglie wavelength by analogy and hence discuss the significance of de Broglie waves.
4. State and explain Heisenberg's Uncertainty principle and give its physical significance.
5. Explain the properties of wavefunction.

7-8 Marks Questions

1. State de Broglie's Hypothesis. Show that the de Broglie wavelength of an electron is found to be equal to $\frac{12.26}{\sqrt{V}}$ Å.
2. Set up the one-dimensional time independent Schrodinger wave equation.
3. Write down the Schrodinger wave equation for a particle in one dimensional box. Obtain the Eigen Functions and Eigen Values for this particle with suitable waveforms.
4. Explain the Wave function with mathematical form and discuss the Physical significance of a wave function.
5. Explain Eigen functions and Eigen Values and hence derive the Eigen function of a particle inside infinite potential well of width 'a'.

Numerical Problems

1. What is the de Broglie wavelength of a proton whose energy is 3eV? Given the mass of proton $=1.67 \times 10^{-27}$ Kg.

2. Calculate the de Broglie wavelength associated with an electron with the kinetic energy of 2000eV.
3. Calculate the kinetic energy of an electron of wavelength 18nm.
4. Calculate the de Broglie wavelength of an electron moving with $1/10^{th}$ part of the velocity of the light.
5. An electron has a speed of 4.8×10^5 m/s accurate to 0.012%. With what accuracy can be located the position of electron?
6. An electron has a speed of 100m/s. the inherent uncertainty in its measurement is 0.005%. What will be the uncertainty that arises in the measurement of its position?
7. In a measurement of position and velocity of an electron moving with the speed of 6×10^5 m/s, calculate the highest accuracy with which its position could be determined if the inherent error in the measurement of its velocity is 0.01% for the speed stated.
8. Calculate the energy in eV for the first excited state of an electron in an infinite potential well of width 2 Å.
9. Calculate the zero-point energy for an electron in a box of width 10 Å.
10. An electron is bound in 1-D potential well of width 0.18nm, find its energy value in eV in the second excited state.
11. The ground state energy of an electron in an infinite well is 5.6×10^{-3} eV. What will be the ground state energy if the width of the well is doubled?

Module-2 Electrical Conductivity in Metals

2 Marks Questions

1. Define drift velocity and give its expression.
2. Define mean free path and give its expression.
3. Define mobility of electrons and give its expression.
4. Define relaxation time or mean collision time.
5. Define current density and give its expression.
6. Define resistivity and give its expression.
7. Define Conductivity and give its expression.
8. What is Density of states? How is it related with energy?
9. Define Fermi factor. Mention its mathematical representation.
10. What are dielectric materials? Give two examples.
11. What is electric polarization? Mention its physical equation.

5 Marks Questions

1. What are the assumptions of quantum free electron theory.
2. Define Density of states, Fermi energy, Fermi factor. Explain with mathematical representation.
3. What are internal fields? Explain.
4. What are electronic polarization and ionic polarization?
5. What are orientation polarization and Space charge polarization.

7-8 Marks Questions

1. Discuss the failures of classical free electron theory.
2. Define Fermi factor and explain its dependence on temperature and energy level.
3. Define Dielectric Polarization. What are the differences between polar and non-polar molecules?
4. Using the internal field expression of the dielectric material, derive Clausius-Mosotti equation.
5. Explain the different types of polarization mechanisms in dielectric materials. Mention an expression for total polarization.

Numerical Problems

1. Calculate the probabilities of an electron occupying an energy level 0.02eV above the fermi level and that in an energy level 0.02eV below the fermi level at 200K.
2. Find the probability that an energy level at 0.2eV below fermi level being occupied at temperatures 300K and 1000K.
3. The fermi level in potassium is 2.1eV what are the energies for which the probabilities of occupancy at 300K are 0.99, 0.01 and 0.5?
4. Find the temperature at which there is 1% probability that a state with an energy 0.5eV above fermi energy is occupied.
5. Find the polarization produced in a crystal by an electric field of strength 500V/mm if it has a dielectric constant of 6?
6. If a NaCl crystal is subjected to an electric field of 1000V/m and the resulting polarization is 4.3×10^{-8} C/m^2, calculate the dielectric constant of NaCl.
7. An elemental solid dielectric material has polarizability 7×10^{-40} Fm^2. Assuming the internal field to be Lorentz filed, calculate the dielectric constant for the material if the material has 3×10^{28} atoms/m^3.

Module-3 Semiconductor Physics

2 Marks Questions

1. What are semiconductors? What are the two types of semiconductors?
2. What are intrinsic semiconductors? Give one example.
3. What are extrinsic semiconductors? What are the two types of extrinsic semiconductors?
4. What are n-type semiconductors? What are the majority charge carriers of n-type semiconductors?
5. What are p-type semiconductors? What are the majority charge carriers of p-type semiconductors?
6. Mention the expression for electron concentration with parameters.
7. Mention the expression for hole concentration with parameters.
8. What is Hall effect and Hall voltage?
9. What is Hall Co-efficient? Mention any two applications of Hall effect.

5 Marks Questions

1. Define Carrier concentration? Mention the expression for hole and electron concentration & explain the terms.
2. Explain the Fermi level in extrinsic semiconductor.
3. What is Hall Effect and Hall Coefficient? Write the expression for hall coefficient & explain the terms.
4. List out any five applications of Hall Effect.

7-8 Marks Questions

1. Explain the variation of Fermi level in intrinsic and extrinsic semiconductor
2. Derive the relation between Fermi energy and energy gap in intrinsic semiconductors or Show that $E_F = \frac{E_g}{2}$ Where the symbols have usual notation.
3. Derive the expression for the electrical conductivity of a semiconductor.
4. With the help of diagram, explain the working principle of four-point probe method. Mention the expression for resistivity of the bulk material & thin sheet of a semiconductor.
5. What is Hall Effect? Derive an expression for Hall coefficient. Mention its applications.

Numerical Problems

1. For intrinsic GaAs, the room temperature electrical conductivity is $10^{-6}/\Omega m$; the electron and hole mobilities are respectively $0.85 m^2/Vs$ and $0.04\ m^2/Vs$. Compute the intrinsic carrier concentration at room temperature.
2. The following data are given for intrinsic Ge at 300K, $n_i = 2.4 \times 10^{19}/m^3$, $\mu_0 = 0.39 m^2/Vs$, $\mu_h = 0.19\ m^2/Vs$. Calculate the resistivity of the sample.
3. The resistivity of the intrinsic Ge at 27^0C is equal to 0.47 Ωm. Assuming electron and hole mobilities as 0.38 and $0.18 m^2/Vs$ respectively, calculate the intrinsic carrier density.
4. The Hall co-efficient of a material is $-3.68 \times 10^{-5}\ m^3/C$. What is the type of charge carriers? Also Calculate the carrier concentration.
5. The hall co-efficient of a specimen of a doped Si is found to be $3.66 \times 10^{-4} m^3/C$. The resistivity of the specimen is $9.93 \times 10^{-3}\ \Omega m$. Find the mobility and density of the charge carrier, assuming single carrier conduction.
6. An n- type Germanium sample as a Donor density of $10^{21}/m^3$ it is arranged in a Hall experiment having magnetic field of 0.5 T and the current density is $500\ A/m^2$. Find the Hall voltage if the sample is 3 mm wide.

Module-4 Superconductivity

2 Marks Questions

1. Define Superconductivity & Superconductors.
2. Draw a graph of temperature v/s resistivity for superconducting state.

3. Define is critical temperature and critical field?
4. Write any four superconducting materials along with their critical temperature.
5. Draw a graph showing temperature dependence on critical field.
6. Write the relation for dependence of critical field on temperature.
7. What is Meissner's Effect? Show magnetic susceptibility (χ) is equal to -1.
8. Write a short note on Type I (soft) Superconductor with diagram.
9. Write a short note on Type II (soft) Superconductor with diagram.
10. Discuss DC Josephson effect.
11. What is SQUID? Give its Acronym.
12. Mention few application of superconductos.

5 Marks Questions

1. Explain Meissner's Effect with diagram.
2. Explain BCS theory for Superconductors.
3. Distinguish between Type-I and Type-II superconductors
4. Explain the construction and working of DC SQUIDS.

7-8 Marks Questions

1. Discuss the discovery of Superconductivity and hence discuss the variation of resistivity with temperature in superconductor with critical temperature as reference.
2. What are superconductors? Explain in detail Meissner's Effect.
3. Discuss Type-I and Type-II superconductors with graphs.
4. What are cooper pairs? Explain BCS Theory for the formation of superconductors.
5. Explain DC Josephson's Junction and its application in DC SQUIDS.

Module 5 - QUANTUM COMPUTING

2 Marks Questions

1. What is Quantum bit or Qubit?
2. Write any two properties of Qubits.
3. Write a short note on Single Qubit.
4. Write a short note on Two Qubits.
5. Write the matrix representation for $|0\rangle$ and $|1\rangle$ states.
6. What is Conjugate Matrix? Give one example.
7. What is Transpose Matrix? Give one example.
8. What is Conjugate Transpose of a Matrix? Give one example.

9. What is Unitary Matrix? Give one example.
10. Write the representation of Bra vector and Ket vector for 0 and 1 state.
11. Show that the two states $|0\rangle$ and $|1\rangle$ are Orthogonal to each other.
12. Give an example for Quantum NOT Gate with matrix.
13. Write the matrix representation for Pauli's X, Y and Z gate.
14. What is Hadamard Gate? Write its matrix representation.
15. Write the Matrix representation and circuit symbol for CNOT gate.
16. Write the Truth table for SWAP Gate.
17. Write the Matrix representation and Truth table for Controlled Z gate.

5 Marks Question

1. Define bit and qubit and explain the properties of qubit.
2. Explain Orthogonality and Orthonormality with an example for each.
3. Explain Hadamard Gate. Show that Hadamard gate is Unitary.
4. Discuss the working of phase gate. Write its matrix representation and truth table.
5. Discuss the working of T gate Write its matrix representation and truth table.
6. What are qubits? Give any four examples for qubits physically.
7. Explain the Matrix representation of $|0\rangle$ and $|1\rangle$ state and apply identity operator I to $|0\rangle$ and $|1\rangle$ states.

7-8 Marks Questions

1. Explain the following matrices with an example
   a. Conjugate of a matrix. b. Transpose of a matrix. c. Unitary Matrix
2. Explain Pauli's X, Pauli's Y and Pauli's Z gate mentioning its matrix representation and operation.
3. Discuss the CNOT gate and its operation on four different input states.
4. Discuss the Swap gate and its operation on four different input states.
5. Describe the working of controlled-Z gate mentioning its matrix representation and truth-table.
6. Explain any one Single qubit gate and one multiple qubit gate with definition, Symbol, Matrix representation and truth table.

Numerical Problems

1. A Linear Operator 'X' operates such that $X|0\rangle = |1\rangle$ and $X|1\rangle = |0\rangle$. Find the matrix representation of 'X'.
2. Given $|\psi\rangle = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}$ and $|\phi\rangle = \begin{bmatrix}\beta_1\\ \beta_2\end{bmatrix}$ Prove that $\langle\psi|\phi\rangle = \langle\phi|\psi\rangle^*$
3. Given, $A = \begin{bmatrix}3 & 3+i\\ 3-i & 2\end{bmatrix}$, check if the given matrix is Hermitian.

4. Prove U = $\begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$ is Unitary.
5. Show that the Matrix U=$\begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{i}{\sqrt{2}} & \frac{-i}{\sqrt{2}} \end{bmatrix}$ is unitary.
6. Find the inner product of states $|1\rangle$ and $|0\rangle$ and draw conclusions on the result.
7. Using Matrix multiplication show that on applying Hadamard gate twice to a $|0\rangle$ results in its original state.
8. Show the Hadamard Gate is Unitary.
9. Show that S gate can be formed by connecting two T gates in Series.