

SSR DEGREE COLLEGE (AUTONOMOUS) NIZAMABAD

M.SC. PHYSICS

Quantum mechanics

Paper 2, Semester 2 Internal 1

I. Multiple choice questions

1. A vector space must satisfy how many basic axioms?

- A) 4
- B) 6
- C) 8
- D) 10

Answer: D) 10

2. The dimension of a vector space is:

- A) Number of vectors in the space
- B) Number of basis vectors
- C) Magnitude of vectors
- D) Rank of matrix only

Answer: B) Number of basis vectors

3. In quantum mechanics, state vectors are usually written using:

- A) Tensor notation
- B) Bra-ket notation
- C) Cartesian notation
- D) Polar notation

Answer: B) Bra-ket notation

4. Which of the following operators always has real eigenvalues in quantum mechanics?

- A) Non-Hermitian operator
- B) Hermitian operator
- C) Singular operator
- D) Unit operator

Answer: B) Hermitian operator

5. The eigenvalue equation in matrix form is:

$$A X = \lambda X$$

Here, X is called:

- A) Determinant
- B) Eigenvector
- C) Trace
- D) Rank

Answer: B) Eigenvector

6. The eigenvalues of a Hermitian operator are always:

- A) Imaginary
- B) Complex
- C) Real
- D) Zero

Answer: C

7.If two eigenfunctions of a Hermitian operator correspond to different eigenvalues, then they are:

- A) Parallel
- B) Equal
- C) Orthogonal
- D) Complex

Answer: C

8.Which property is true for Hermitian matrices?

- A) Diagonal elements are imaginary
- B) Eigenvalues are real
- C) Trace is imaginary
- D) Determinant is always zero

Answer: B

9.The Hamiltonian operator in quantum mechanics is generally:

- A) Anti-Hermitian
- B) Hermitian
- C) Imaginary
- D) Singular

Answer: B

10. The parity operator is:

- A) Non-linear
- B) Hermitian
- C) Anti-Hermitian
- D) Singular

Answer: B) Hermitian

11.Which operator remains unchanged under parity transformation?

- A) Position
- B) Momentum
- C) Angular momentum
- D) Velocity

Answer: C) Angular momentum

12.The parity operator mainly represents:

- A) Time reversal
- B) Space inversion
- C) Rotation
- D) Translation

Answer: B) Space inversion

13.The parity of the product of two odd functions is:

- A) Odd
- B) Even
- C) Zero
- D) Undefined

Answer: B) Even

14. In the Schrödinger picture, the time dependence is carried by

- A) Operators only
- B) State vectors only
- C) Both operators and state vectors
- D) Neither

Answer: B) State vectors only

15. In the Heisenberg picture, which quantity changes with time?

- A) State vectors
- B) Operators
- C) Eigenvalues
- D) Wave function only

Answer: B) Operators

16. Which picture is also called matrix mechanics?

- A) Schrödinger picture
- B) Interaction picture
- C) Heisenberg picture
- D) Wave mechanics

Answer: C) Heisenberg picture

17. In a simple harmonic oscillator, the restoring force is

- A) Constant
- B) Directly proportional to displacement
- C) Inversely proportional to displacement
- D) Independent of displacement

Answer: B

18. The radial wave function for hydrogen atom involves:

- A) Bessel polynomials
- B) Hermite polynomials
- C) Legendre polynomials
- D) Laguerre polynomials

Answer: D) Laguerre polynomials

19. The normalized radial wave function ensures that:

- A) Electron energy becomes zero
- B) Total probability is unity
- C) Radius becomes constant
- D) Momentum becomes zero

Answer: B) Total probability is unity

20. Which orbital has one radial node?

- A) 1s
- B) 2s
- C) 2p
- D) 3p

Answer: B) 2s

II. Fill in the blanks

1. A collection of vectors satisfying addition and scalar multiplication rules is called a **vector space**.
2. In quantum mechanics, vectors are usually represented by **kets**.
3. The notation for a ket vector is $|\psi\rangle$
4. Two vectors are orthogonal if their inner product is **zero**.
5. A vector whose magnitude is one is called a **normalized vector**.
6. The expectation value of a Hermitian operator is always **real**
7. The matrix representation of a Hermitian operator is equal to its **conjugate transpose**
8. Two operators are said to commute if their **commutator** is zero.
9. Non-commuting operators generally do not share the same **eigenfunctions**.
10. Angular momentum components are generally **non-commuting** operators.
11. In the Heisenberg picture, observable quantities evolve with ____.
Answer: time
12. The operator responsible for time evolution is the ____ operator.
Answer: evolution
13. The Schrödinger picture is more useful in dealing with ____ functions directly.
14. The radial equation contains the quantum number __, called the azimuthal (orbital) quantum number.
Answer: l
15. For a hydrogen atom, the energy eigenvalues depend only on the quantum number ____.
Answer: n
16. The radial wave functions are expressed in terms of __ polynomials.
Answer: Laguerre
17. A stationary state is an eigenstate of the __ operator.
Answer: Hamiltonian
18. In a stationary state, the probability density is __ with time.
Answer: constant (independent)
19. A stationary state remains unchanged except for a time-dependent __ factor.
Answer: phase
20. The energy eigenfunctions of a Hermitian Hamiltonian are __ to each other.
Answer: orthogonal
21. The superposition of two stationary states is generally __ a stationary state.
Answer: not

III. Short answer questions

1. What are commuting and non commuting operators
2. define hermitian operators and their properties
3. define parity operator write it's significance
4. define the interaction picture
5. differentiate schrodinger and heisenberg picture
6. obtain the solution to linear harmonic oscillator