Quantum Physics I

Exam-Ready Study Notes

■ **Source Material**	Introduction to Quantum Mechanics
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■ **Edition**	3rd Edition
■ **Generated**	January 31, 2026
■ **Topics Covered**	2

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Chapter 1: The Wave Function

Topic 1: Quantum Superposition

The principle of **superposition** is a fundamental concept in quantum mechanics. It states that when two or more quantum states are possible, the actual state is a **superposition** (combination) of all possible states until a **measurement** is made.

The **wave function** $\psi(x,t)$ contains all information about the quantum state. When measured, the **wave function collapse**s to a single eigenstate. The probability of finding a particle at position x is given by $|\psi(x,t)|^2$.

Key points:
1. Multiple states can exist simultaneously
2. Measurement causes **wave function collapse**
3. Probability is determined by **wave function** amplitude squared
4. Superposition is destroyed upon observation

■ **Key Terms:**

- **superposition**
- **wave function**
- **measurement**
- **collapse**

■ *Exam Note: This topic appeared 3 times in past papers with 10 marks weightage.*

■ ***Source:*** *Introduction to Quantum Mechanics, Chapter 1, Page 12*

Topic 2: Heisenberg Uncertainty Principle

The Heisenberg Uncertainty Principle is a fundamental limitation in quantum mechanics that states we cannot simultaneously know both the exact **position** and exact **momentum** of a particle.

Mathematical formulation: $\Delta x \cdot \Delta p \geq$ ■/2

Where:
- Δx is the uncertainty in **position**
- Δp is the uncertainty in **momentum**

- ■ is the reduced **Planck constant** (h/2π)

This is not due to measurement limitations, but rather a fundamental property of nature.
The more precisely we know **position**, the less precisely we can know **momentum**, and vice versa.

Applications:
1. Explains stability of atoms
2. Sets limits on measurement precision
3. Fundamental to quantum field theory
4. Basis for quantum cryptography

■ **Key Terms:**

- **uncertainty principle**
- **position**
- **momentum**
- **Planck constant**

■ *Exam Note: This topic appeared 5 times in past papers with 15 marks weightage.*

■ ***Source:*** *Introduction to Quantum Mechanics, Chapter 1, Page 24*

Topic 3: Heisenberg Uncertainty Principle

The Heisenberg Uncertainty Principle is a fundamental limitation in quantum mechanics
that states we cannot simultaneously know both the exact **position** and exact **momentum** of a particle.

Mathematical formulation: $\Delta x \cdot \Delta p \geq$ ■/2

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Applications:
1. Explains stability of atoms
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■ **Key Terms:**

- **uncertainty principle**
- **position**
- **momentum**
- **Planck constant**

■ *Exam Note: This topic appeared 5 times in past papers with 10 marks weightage.*

■ ***Source:*** *Introduction to Quantum Mechanics, Chapter 1, Page 24*

Topic 4: Quantum Superposition

The principle of **superposition** is a fundamental concept in quantum mechanics. It states that when two or more quantum states are possible, the actual state is a **superposition** (combination) of all possible states until a **measurement** is made.

The **wave function** $\psi(x,t)$ contains all information about the quantum state. When measured, the **wave function collapse**s to a single eigenstate. The probability of finding a particle at position x is given by $|\psi(x,t)|^2$.

Key points:
1. Multiple states can exist simultaneously
2. Measurement causes **wave function collapse**
3. Probability is determined by **wave function** amplitude squared
4. Superposition is destroyed upon observation

■ **Key Terms:**

- **superposition**
- **wave function**
- **measurement**
- **collapse**

■ *Exam Note: This topic appeared 3 times in past papers with 10 marks weightage.*

■ ***Source:*** *Introduction to Quantum Mechanics, Chapter 1, Page 12*

Chapter 1 Summary: This chapter covered 4 important exam topics. Focus on understanding the key concepts and practice related problems.

Chapter 2: The Schrödinger Equation

Topic 5: Time-Independent Schrödinger Equation

The time-independent **Schrödinger equation** is the fundamental equation for stationary quantum states:

$\blacksquare\psi = E\psi$

Or in expanded form: $-\blacksquare^2/2m \cdot d^2\psi/dx^2 + V(x)\psi = E\psi$

Where:
- ■ is the **Hamiltonian** operator (total energy)
- ψ is the **wave function**
- E is the energy **eigenvalue**
- V(x) is the potential energy
- m is the particle mass

This equation allows us to find allowed energy levels and corresponding **wave function**s for quantum systems. Solutions must be:
1. Continuous
2. Single-valued
3. Normalizable
4. Smooth (continuous first derivative)

Common applications:
- Particle in a box
- Harmonic oscillator
- Hydrogen atom
- Quantum tunneling

■ Key Terms:

- **Schrödinger equation**
- **Hamiltonian**
- **eigenvalue**
- **wave function**

■ *Exam Note: This topic appeared 4 times in past papers with 20 marks weightage.*

■ ***Source:*** *Introduction to Quantum Mechanics, Chapter 2, Page 45*

Chapter 2 Summary: This chapter covered 1 important exam topics. Focus on understanding the key concepts and practice related problems.

End of Study Notes

■ Review all key terms highlighted in blue
■ Practice questions from each chapter
■ Focus on high-frequency topics
■ Refer to source material for deeper understanding

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