

Quantum Mechanical Model

Structure of Atom | JEE Class 11 Chemistry

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The Paradigm Shift: Classical vs. Quantum



Classical Mechanics

Scale: Macroscopic

Applies to: Planets, stones, heavy objects.

Governing Rule: Newton's Laws of Motion.

Behavior: Fixed, predictable trajectories.
Position and momentum can be known exactly.



Quantum Mechanics

Scale: Microscopic

Applies to: Electrons, atoms, molecules.

Governing Rule: Heisenberg & Schrödinger equations.

Behavior: Dual nature (wave-particle).
Dictated by the Uncertainty Principle.

The Governing Law

Hamiltonian Operator

The mathematical recipe for total energy (Kinetic + Potential).

Total Energy

The quantized, allowed energy levels.

$$\hat{H}\psi = E\psi$$

Wave Function

The state of the system.



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$$E=mc^2$$



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Key Highlights

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The Wave Function (ψ)

The Ultimate Information Store

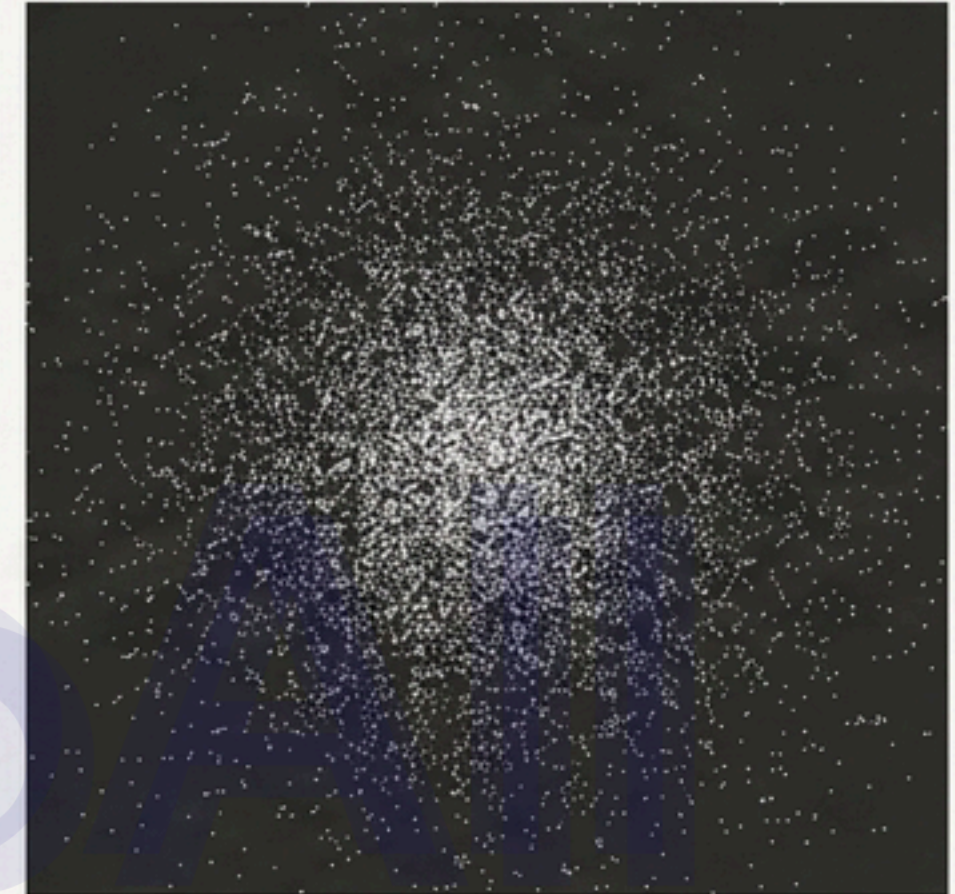


- **Core Concept:** ψ is a purely mathematical function. It has **no physical meaning** by itself.
- **Function:** It stores all possible information about an electron in a specific energy state.
- **Extraction:** Quantum mechanics provides the mathematical tools to extract usable physical data (like energy and position probability) from ψ .

The Physical Reality: Probability Density

$$|\psi|^2$$

While ψ means nothing alone, its square represents the physical probability of finding an electron at a specific point in space.



- Always **positive**.
- **Higher dot density** = higher probability region.
- **Nodes**: Regions in space where $|\psi|^2 = 0$ (zero probability of finding an electron).

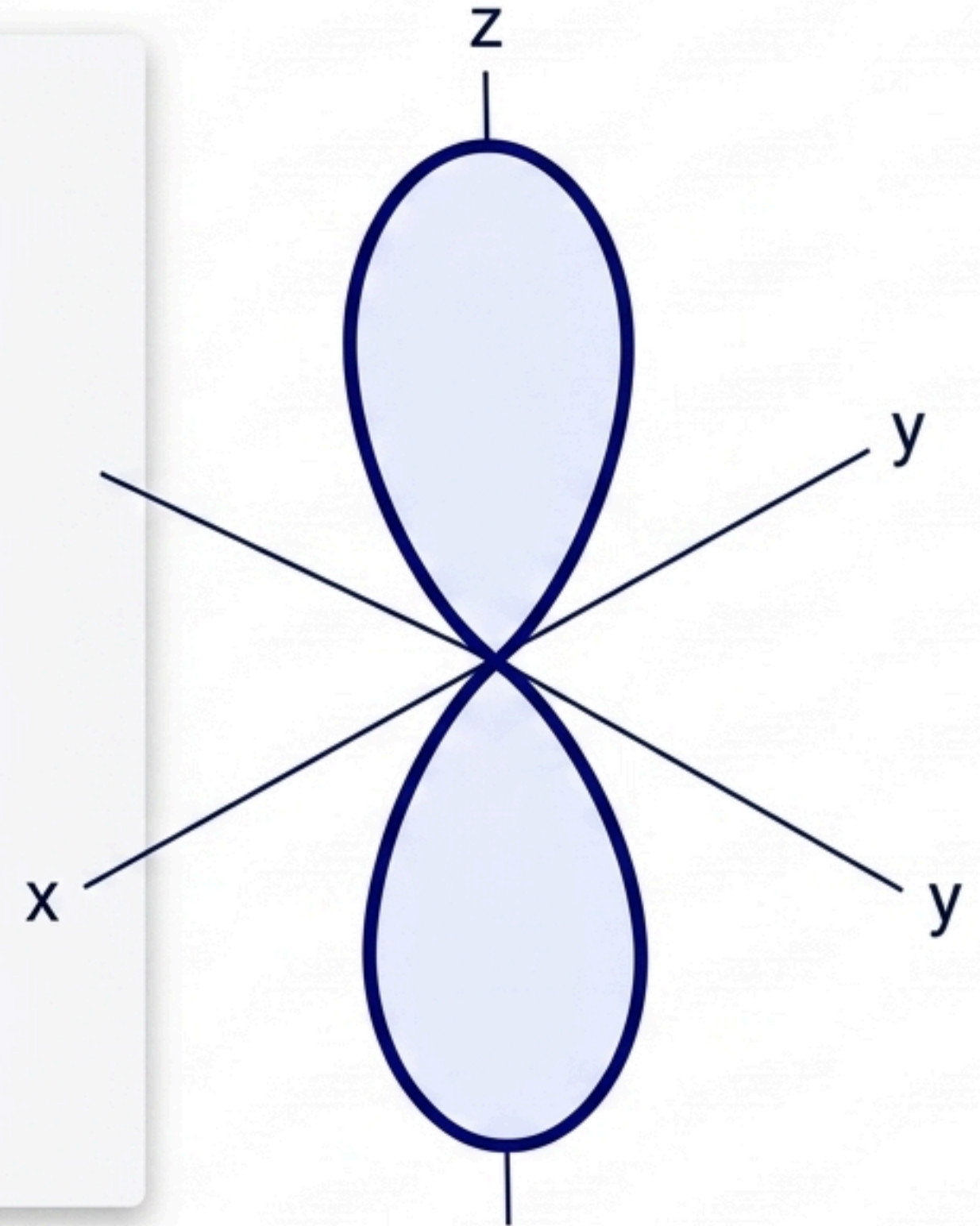
Redefining the Electron's Home: The Orbital

Definition:

An atomic orbital is simply a one-electron wave function (ψ) in an atom.

Characteristics:

- Whenever an electron is described by ψ , it is said to occupy that orbital.
- Represented graphically by Boundary Surface Diagrams, enclosing the region of $\sim 90\%$ probability.
- Fully defined by 3 quantum numbers: n , l , m_l



⚠ TRAP: Orbit $\neq$ Orbital

Orbit (Bohr Model)

- **Concept:** Fixed, circular 2D path.
- **Properties:** Definite, exact position & momentum.
- **Validity:**
Violates Heisenberg's Uncertainty Principle.

Orbital (Quantum Model)

- **Concept:** 3D spatial region of probability density ($|\psi|^2$).
- **Properties:** Indicates likelihood, not an exact path.
- **Validity:**
Obeys Heisenberg's Uncertainty Principle.

Key Takeaways

The quantum model predicts **PROBABILITY**, not fixed paths.

- Classical mechanics fails for microscopic particles due to wave-particle duality.
- The wave function (ψ) is purely abstract math; its square ($|\psi|^2$) is the physical probability density.
- Electrons exist in 3D probability clouds (**orbitals**), completely replacing the 2D planetary orbits of the Bohr model.



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