Quantum Mechanics & Matter Waves – Cheat Sheet (Theory Only)

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1. Matter Waves & de Broglie Wavelength

Matter waves describe the wave-like nature of particles.
Proposed by **Louis de Broglie**, stating that **particles exhibit both wave and particle properties**.
Used in **electron microscopy, quantum computing, and nanotechnology**.

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2. Heisenberg's Uncertainty Principle

States that **it is impossible to simultaneously determine both the exact position and momentum of a particle**.
The principle shows the **fundamental limit of measurement accuracy in quantum systems**.
Applications:

- Explains **why electrons don't collapse into the nucleus**.
- Used in **quantum cryptography and microscopy**.

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3. Physical Significance of Wave Function (Ψ)

Wave function (Ψ) represents the **quantum state of a particle**.
Ψ itself has **no direct physical meaning**, but **Ψ^2 represents the probability density** of finding a particle in a given location.
Used in **quantum mechanics, atomic structure, and molecular bonding**.

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4. Schrödinger Wave Equation

(a) Time-Dependent Schrödinger Equation

Describes **how the quantum state of a system evolves over time**.
Used in **quantum computing, spectroscopy, and particle physics**.

(b) Time-Independent Schrödinger Equation

Used for **steady-state systems** where energy remains constant.
Helps in **solving potential energy problems, atomic structures, and solid-state physics**.

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5. Application: Particle in a One-Dimensional Box

Describes a **particle confined to a region with infinite potential barriers**.
Key results:

- **Energy is quantized** (Discrete energy levels exist).
- **Wave-like behavior of particles is evident**.
- Used in **quantum dots, nanotechnology, and semiconductor physics**.

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6. Tunnel Diode & Quantum Tunneling

Quantum tunneling allows particles to **pass through potential barriers** that they classically shouldn't.
Tunnel Diode: A semiconductor device using tunneling for **high-speed switching and low-power operation**.
Applications of **Quantum Tunneling:**

- **Scanning Tunneling Microscope (STM)**

- **Nuclear Fusion in Stars**
- **Flash Memory & Quantum Computing**

This **Quantum Mechanics Cheat Sheet** covers **matter waves, de Broglie wavelength, uncertainty principle, wave functions, Schrödinger equation, particle in a box, and tunnel diodes**. Let me know if you need further explanations!