Key Quantum Mechanics Equations

1. Schrödinger's Equation

The time-dependent Schrödinger equation is given by:

$$i\hbar\frac{\partial\psi(\mathbf{r},t)}{\partial t} = \hat{H}\psi(\mathbf{r},t)$$

where:

- i is the imaginary unit,
- $\hbar$ is the reduced Planck's constant,
- $\psi(\mathbf{r},t)$ is the wave function,
- $\hat{H}$ is the Hamiltonian operator.

The time-independent Schrödinger equation is:

$$\hat{H}\psi(\mathbf{r}) = E\psi(\mathbf{r})$$

where E is the energy eigenvalue.

2. Heisenberg Uncertainty Principle

The Heisenberg uncertainty principle is expressed as:

$$\Delta x\Delta p \geq \frac{\hbar}{2}$$

where:

- Δx is the uncertainty in position,
- Δp is the uncertainty in momentum.

3. Born Rule

The Born rule relates the wave function to probability:

$$P(x) = |\psi(x)|^2$$

where $P(x)$ is the probability density of finding a particle at position x.

4. Commutation Relation

The fundamental commutation relation between position and momentum operators is:

$$[\hat{x},\hat{p}] = i\hbar$$

where:

- $\hat{x}$ is the position operator,
- $\hat{p}$ is the momentum operator.

5. Pauli Exclusion Principle

The Pauli exclusion principle states that no two fermions can occupy the same quantum state:

$$\psi(1,2) = -\psi(2,1)$$