THE POSTULATES OF QUANTUM MECHANICS

Postulate I (<u>The system is described by a wavefunction</u>)

Any dynamical system of n particles is described as completely as possible by the wavefunction $\Psi\left(q_1,q_2,\ldots,q_{3n};\omega_1,\omega_2,\ldots,\omega_n;t\right)$, where the q's are spatial coordinates (3 per particle), ω's are spin coordinates (1 per particle), and t is the time coordinate. $\Psi^*\Psi d\tau$ is the probability that the space-spin coordinates lie in the volume element $d\tau$ $(\equiv d\tau_1 d\tau_2 \cdots d\tau_n)$ at time t, if Ψ is normalized.

Postulate II (<u>Physical observables are associated with hermitian operators</u>)

To every observable dynamical variable M (a classical physical observable), we associate a hermitian operator $\hat{M}$ by :

(1) write the classical expression as fully as possible in terms of <u>cartesian</u> momenta (p) and positions (q)

(2) if M is q or t, $\hat{M}$ is q or t

(3) if M is a momentum, p_q, the operator is $-i\hbar\frac{\partial}{\partial q}$, where q is conjugate to p (e.g., x is conjugate to p_x).

(4) If M is expressible in terms of q's, p's, and t, $\hat{M}$ is found by substituting the above operators in the expression for M. Nearly always this will provide a hermitian operator.

Postulate III (<u>Wavefunctions are solutions of the TDSE</u>)

The wavefunctions (or state functions) satisfy the time <u>dependent</u> Schrödinger equation

$$\hat{H}\,\Psi(q,t) = i\hbar\frac{\partial}{\partial t}\Psi(q,t)$$

where $\hat{H}$ is the hamiltonian operator for the system.

Postulate IV (Precise measurements: eigenvalues/eigenfunctions)

If Ψ_b is an eigenfunction of the operator $\hat{B}$ with eigenvalue b, then if we make a measurement of the physical observable represented by $\hat{B}$ for a system whose wavefunction is Ψ_b, we <u>always</u> obtain b as the result.

Postulate V (Imprecise measurements: average or expectation values)

When a large number of identical systems have the same wavefunction Ψ, the expected average ("expectation value") of measurements on the observable M (one measurement per system) is given by

$$\langle M \rangle = \frac{\int \Psi^* \ \hat{M} \Psi \, d\tau}{\int \Psi^* \ \Psi \, d\tau}$$

(The denominator equals one if Ψ is normalized.)

Note that if Ψ is an eigenfunction of the operator $\hat{M}$, this postulate reverts to Postulate IV.