THE POSTULATES OF QUANTUM MECHANICS

Postulate I (The system is described by a wave function)

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

Postulate II (Physical observables are associated with hermitian operators)

To every observable dynamical variable *M* (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 and positions
(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 (Wave functions are solutions of the TDSE)

The state functions (or wavefunctions) satisfy the time dependent 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 always 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.