POSTULATES OF QUANTUM MECHANICS

Dr. Pradeep Samantaroy

Department of Chemistry

Rayagada Autonomous College, Rayagada

pksroy82@gmail.com; pksroy82@yahoo.in

9444078968

Postulate 1

The physical state of a system at time t is described by the wave function $\Psi(x, t)$.

<u>Postulate 2</u>

The wave function Ψ (x, t) and its first and second derivative must satisfy the following conditions:

Finite

Continuous

Single valued

Must satisfy the ortho-normal condition

Ortho-normal Condition

Considering one dimension:

$$\int_{-\infty}^{\infty} |\psi(x)|^2 \, dx = \int_{-\infty}^{\infty} \psi^*(x)\psi(x)dx = 1$$

Considering three dimension:

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} |\psi(x,y,z)|^2 \, dxdydz = 1$$

Normalized condition:

$$\int |\psi|^2 \, d\tau = \int \psi^* \psi d\tau = 1$$

Orthogonal condition:

$$\int \psi_j^* \psi_k d\tau = 0$$

Orthonormal condition:

$$\int \psi_j^* \psi_k d\tau = \delta_{jk}$$

$$\delta_{jk} = \begin{cases} 0, & j \neq k \\ 1, & j = k \end{cases}$$

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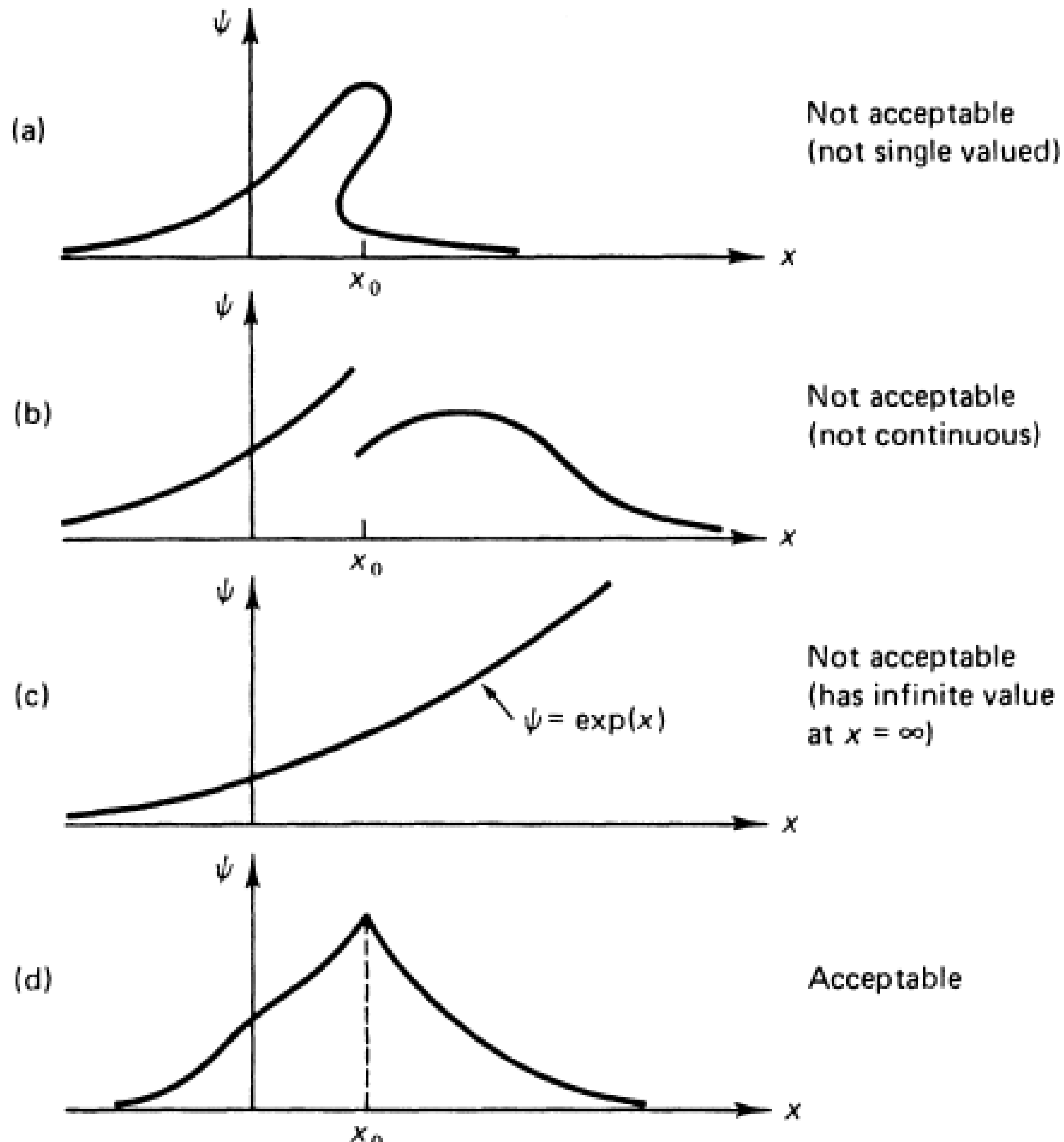
ψ
(a)
Not acceptable
(not single valued)
x_0
x
(b)
Not acceptable
(not continuous)
(c)
$\psi = \exp(x)$
Not acceptable
(has infinite value
at $x = \infty$)
(d)
Acceptable

Which if the following are acceptable functions:

a) $\psi = x$
b) $\psi = x^2$
c) $\psi = \sin x$
d) $\psi = \exp(-x)$
e) $\psi = \exp(-x^2)$

Postulate 3

A physically observable quantity can be represented by a Hermitian operator.

An operator Â is said to be Hermitian if it satisfies the following condition.

$$\int \Psi_i^* \hat{A} \Psi_j dx = \int \Psi_j \ (\hat{A}\Psi_i)^* \, dx$$

Where Ψ_i and Ψ_j are wave functions representing the physical states of quantum systems.

Postulate 4

The allowed values of an observable A are the eigenvalues, $a_{i,}$ in the operator equation

$$\hat{A}\Psi_i = a_i\Psi_i$$

Where $\hat{A}$ is the operator
Ψ_i is the eigen function
a_i is the eigen value

An eigen function is for an operator d^2/dx^2 is $\Psi = e^{2x}$.

Find the corresponding eigen value.

$$d^2/dx^2 \ (e^{2x}) = d/dx \{d/dx\ (e^{2x})\}$$

$$= d/dx\ (2.\ e^{2x})$$

$$= 2.\ 2.\ e^{2x}$$

$$= 4\ e^{2x}$$

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Postulate 5

The average value/expectation value of A i.e. <A>, corresponding to Â, is obtained from the relation

$$< \boldsymbol{A} > = \int_{-\infty}^{\infty} \boldsymbol{\Psi}^* \, \hat{\mathrm{A}} \, \boldsymbol{\Psi} \, \boldsymbol{dx}$$

Postulate 6

The quantum mechanical operators corresponding to the observables are constructed by writing the classical expression in terms of the variable and converting the expressions to the operators.

Classical variable	Quantum mechanical operator	Operator	Operation
x	$\hat{x}$	x	Multiplication by x
p_x	$\hat{p}_x$	$-i\hbar\dfrac{\partial}{\partial x}$	Taking derivative with respect to x and multiplying by $-i\hbar$
x^2	$\hat{x}^2$	x^2	Multiplication by x^2
p_x^2	$\hat{p}_x^2$	$-\hbar^2\dfrac{\partial^2}{\partial x^2}$	Taking second derivative with respect to x and multiplying by $-\hbar^2$
t	$\hat{t}$	$\hat{t}$	Multiplying by t
E	$\hat{E}$	$i\hbar\dfrac{\partial}{\partial t}$	Taking derivative with respect to t and multiplying by $i\hbar$