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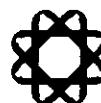
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Q.1) Quantum mechanics is the branch of physics where we studied about to tiny particle which deals with the wave mechanics.

Postulates:

- (i) It must be differential
- (ii) It must be continuous
- (iii) It must be normalized
- (iv) It must have a Singled Value
- (v) It must follow the normalized continuity condition from all space.
- (vi) It must have  $|\psi|^2$
- (vii) the state of System must be defined by  $\psi$
- (viii) The probability of finding the particle is given by  $|\psi|^2$
- (ix) The probability of finding any particle is positive so Wave function is given as  $|\psi|^2$
- (x) It must be Square Integrable.



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$$(b) |\Psi_0\rangle = \frac{1}{\sqrt{2}} |\phi_1\rangle + \frac{i}{2} |\phi_2\rangle + \frac{1}{2} |\phi_3\rangle \quad \dots \text{ (Given)}$$

$$|\Psi\rangle = \frac{1}{\sqrt{3}} |\phi_1\rangle + \frac{i}{\sqrt{3}} |\phi_3\rangle \quad \dots \text{ (Given)}$$

Soln:

$$|\Psi_0\rangle = \frac{1}{\sqrt{2}} |\phi_1\rangle + \frac{i}{2} |\phi_2\rangle + \frac{1}{2} |\phi_3\rangle \quad \dots \text{ (1)}$$

$$\langle \Psi_0 | = \frac{1}{\sqrt{2}} \langle \phi_1 | + -\frac{i}{2} \langle \phi_2 | + \frac{1}{2} \langle \phi_3 | \quad \dots \text{ (1')}$$

for normalise  $\langle \Psi_0 | \Psi_0 \rangle = 1$ 

$$\therefore \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}} - \frac{i}{2} \times \frac{i}{2} + \frac{1}{2} \times \frac{1}{2} \checkmark$$

$$= \frac{1}{2} + \frac{1}{4} + \frac{1}{4} \quad Q2 \rightarrow 10$$

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$$= \frac{1}{2} + \frac{2}{4}$$

$$= \frac{1}{2} + \frac{1}{2}$$

$$= 1$$

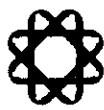
Hence  $|\Psi_0\rangle$  is normalisedNow,

$$|\Psi_1\rangle = \frac{1}{\sqrt{3}} |\phi_1\rangle + \frac{i}{\sqrt{3}} |\phi_3\rangle \quad \dots \text{ (From Given)} \quad \text{--- (1)}$$

$$\langle \Psi_1 | = \frac{1}{\sqrt{3}} \langle \phi_1 | + -\frac{i}{\sqrt{3}} \langle \phi_3 | \quad \text{--- (1')}$$

 $\therefore$  Now: for normalised condition

$$\langle \Psi_1 | \Psi_1 \rangle = 1$$



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$$\therefore \frac{1}{\sqrt{3}} \times \frac{1}{\sqrt{3}} - \frac{i}{\sqrt{3}} \times \frac{i}{\sqrt{3}}$$

$$\therefore \frac{1}{3} + \frac{1}{3}$$

$$\therefore \frac{2}{3} \neq 1$$

$\therefore |\Psi_1\rangle$  is not normalised

$$\text{Hence; } \langle \Psi_0 | = \frac{1}{\sqrt{2}} |\Psi_1\rangle + -\frac{i}{2} |\Psi_2\rangle \text{ and ... (from m 1)}$$

$$|\Psi_1\rangle = \frac{1}{\sqrt{3}} (\Psi_1) + \frac{i}{\sqrt{3}} (\Psi_2) \quad \dots \text{ (from given)}$$

$$\therefore \langle \Psi_0 | \Psi_1 \rangle = \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{3}} - \frac{i}{2} + \frac{i}{\sqrt{3}} \times \frac{1}{2}$$

$$= \frac{1}{\sqrt{6}} - \frac{i}{2} + \frac{i}{2\sqrt{3}} \quad Q3 \rightarrow 0$$

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$$= \frac{1}{\sqrt{6}} - i \left( \frac{1}{2} - \frac{1}{2\sqrt{3}} \right)$$

$$\boxed{\langle \Psi_0 | \Psi_1 \rangle = \frac{1}{\sqrt{6}} - i \left( \frac{\sqrt{3}-1}{2\sqrt{3}} \right)}$$

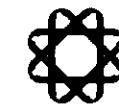
and

$$\langle \Psi_1 | = \frac{1}{\sqrt{3}} |\Psi_1\rangle - \frac{i}{\sqrt{3}} |\Psi_2\rangle \quad |\Psi_0\rangle = \frac{1}{\sqrt{2}} |\Psi_1\rangle + \frac{i}{2} |\Psi_2\rangle + \frac{1}{2} |\Psi_3\rangle$$

$$\therefore \langle \Psi_1 | \Psi_0 \rangle = \frac{1}{\sqrt{6}} + \frac{i}{2} - \frac{i}{2\sqrt{3}}$$

$$= \frac{1}{\sqrt{6}} + i \left( \frac{1}{2} - \frac{1}{2\sqrt{3}} \right)$$

$$\boxed{\langle \Psi_1 | \Psi_0 \rangle = \frac{1}{\sqrt{6}} + i \left( \frac{\sqrt{3}-1}{2\sqrt{3}} \right)}$$



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(3)  $V(x) = \infty \quad x < 0 \quad \text{and} \quad x > a$   
 $= -V_0 \quad 0 < x < \frac{a}{2}$

Solution:-

$$\text{Here } \psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$$

Now 1st order correction is given as

$$E_n^{(1)} = \langle \psi_n^{(0)} | H' | \psi_n^{(0)} \rangle$$

$$E_n^{(1)} = \int_{-\infty}^{\infty} \psi_n^{(0)*} H' \psi_n^{(0)} dx \quad \checkmark$$

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$$= \int_0^a \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right) \times (-V_0) \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right) dx$$

$$= \frac{2}{a} (-V_0) \int_0^a \sin^2\left(\frac{n\pi x}{a}\right) dx$$

$$= \frac{2}{a} (-V_0) \int_0^a 1 - \cos\left(\frac{2n\pi x}{a}\right) dx$$

$$= -\frac{V_0}{a} \int_0^a 1 - \cos\left(\frac{2n\pi x}{a}\right) dx$$

$$= -\frac{V_0}{a} \left[ \int_0^a 1 dx - \int_0^a \cos\left(\frac{2n\pi x}{a}\right) dx \right]$$

$$= -\frac{V_0}{a} \left[ [x]_0^a - \left[ \frac{\sin\left(\frac{2n\pi x}{a}\right) \times a}{2n\pi} \right]_0^a \right]$$



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$$\therefore -\frac{v_0}{a} [2]_0 - \left[ \sin\left(\frac{2n\pi a}{a}\right) \times \frac{a}{2n\pi} - \sin(0) \times \frac{a}{2n\pi} \right]$$

$$\therefore -\frac{v_0}{a} [a-0] = 0$$

$$= -\frac{v_0}{a} (a)$$

$$= -v_0$$

$$\therefore [E_n^{(1)} = -v_0]$$



(c)

Soln:

Q4 -&gt; 10

$$\hat{H}_1 = \begin{bmatrix} E_0 + \epsilon & 0 \\ 0 & E_0 - \epsilon \end{bmatrix} \quad \text{and} \quad H' = \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix}$$

Soln:

$$\text{here } |H' - E^{\infty} I| = 0$$

$$\therefore \left| \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix} - E^{\infty} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \right| = 0$$

$$\therefore \left| \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix} - \begin{bmatrix} E_n^{(1)} & 0 \\ 0 & E_n^{(1)} \end{bmatrix} \right| = 0$$

for 2nd Order

$$\therefore \left| \begin{bmatrix} -E_n^{(1)} & A \\ A & -E_n^{(1)} \end{bmatrix} \right| = 0$$

$$E_n^{(2)} = \frac{2 \psi_{n(1)} (H' | H_1^{\infty})}{E_n^{(1)} - E_m^{(1)}}$$

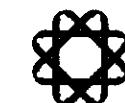
$$\therefore (E_n^{(1)})^2 - A^2 = 0$$

$$\therefore (E_n^{(1)})^2 = A^2$$

$$\therefore E_n^{(1)} = \pm A$$

$$E_n^{(2)} = \frac{A^2}{2\lambda}$$

1st Order Correction of Energy



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(S)

- (a) It is a mathematical term used as the notation in the Quantum mechanics as the wave function such that

$$\delta(x) = \begin{cases} 0 & x \neq 0 \\ \infty & x = 0 \end{cases}$$

on changing the scale

$$\delta(x - x_0) = \begin{cases} 0 & x \neq x_0 \\ \infty & x = x_0 \end{cases}$$

$$\text{Here } \delta(x) \delta(x - x_0) = 1$$

Q5 -&gt; 0

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$$\textcircled{1} \quad \int_{-\infty}^{\infty} \delta(x) \delta(x - x_0) = 1$$

$$\textcircled{2} \quad \int_a^b \delta(x) \delta(x - x_0) = f(x_0)$$

$$\textcircled{3} \quad \int_a^b f(x) \delta(x - c) = f(c)$$

as  $c$  lies between  $a$  and  $b$

$$\textcircled{4} \quad \int_{-\infty}^{\infty} f(x) \delta(x - c) = 0$$

as  $c$  does not lie in between  $a$  and  $b$

$$\textcircled{5} \quad \delta(a) = \lim_{x \rightarrow a} \delta(x)$$

$$\textcircled{6} \quad \delta(-x) = \delta(x)$$

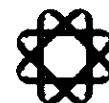
$$\textcircled{7} \quad \frac{d}{dx} f(x) = f'(x)$$

$$\textcircled{8} \quad x \delta(x) = 0$$

$$\textcircled{9} \quad \delta(a-x) \delta(x-b) = \delta(a-b)$$



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		(U) $\delta(a-b) = \delta(b-a)$
		(A) $\int_{-\infty}^{\infty} \delta(x) = 1$
		(R) $\int_{-\infty}^{\infty} f(x) \delta(x) = 1$
		(C) <u>Soln:</u>
		$\hat{x} = \left(\frac{\hbar}{2mw}\right)^{1/2} (a + a^\dagger)$
		External perturbation $\hat{x}' = bx$ ✓
		Q6 -> 0
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		<u>Now,</u>
		1st order correction to the Energy of the oscillator is given as
		$E_n^{(1)} = \langle \Psi_n^{(0)}   H'   \Psi_n^{(0)} \rangle$
		$= \langle \Psi_n^{(0)}   b \hat{x}'   \Psi_n^{(0)} \rangle_{(a+a^\dagger)}$
		$= \langle \Psi_n^{(0)}   \left(\frac{\hbar}{2mw}\right)^{1/2} b   \Psi_n^{(0)} \rangle$
		$= \left(\frac{\hbar}{2mw}\right)^{1/2} b \langle \Psi_n^{(0)}   (a + a^\dagger)   \Psi_n^{(0)} \rangle$
		$= \left(\frac{\hbar}{2mw}\right)^{1/2} b \langle \Psi_n^{(0)}   (a + a^\dagger)   \Psi_n^{(0)} \rangle = 0$
		$E_n^{(1)} = 0$ , as $(a + a^\dagger) = 0$ for

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Q7 → 10

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**HBSU**

# **Booklet Name: 1900162757 (1)-1-10.pdf**

<b>Question</b>	<b>Marks</b>	<b>Time</b>	<b>Evaluator</b>
Q2	10	11/28/2025, 3:37:27 PM	jwerry@gmail.com
Q3	0	11/28/2025, 3:37:33 PM	jwerry@gmail.com
Q3	10	11/28/2025, 3:37:47 PM	jwerry@gmail.com
Q4	10	11/28/2025, 3:37:53 PM	jwerry@gmail.com
Q5	0	11/28/2025, 3:37:57 PM	jwerry@gmail.com
Q6	0	11/28/2025, 3:38:02 PM	jwerry@gmail.com
Q6	10	11/28/2025, 3:38:07 PM	jwerry@gmail.com
Q7	10	11/28/2025, 3:38:22 PM	jwerry@gmail.com

**Total Marks: 50**