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Space for Marks	Question No.	
	Q.1)	Quantum mechanics is the branch of physics where we studied about to tiny particle which deals with the wave mechanics.

Postulates:-

(i) ψ must be differential

(ii) ψ must be continus

(iii) ψ must be normulized

(iv) It must have a singled value

(v) It must flow the norlized continual condition from all space.

(vi) It must have $|\psi|^2$

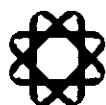(vii) the State of systkm must be defind by ψ

Q2 -> 10

(viii) the probality of finding the particle is given by $|\psi|^2$

(ix) The probality of finding any particle is positive so wave function is given as $|\psi|^2$

(x) It must be squre integral

Q10 -> 10

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(b) $|\psi_0\rangle = \frac{1}{\sqrt{2}}|\phi_1\rangle + \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ ... (Given

$|\psi_1\rangle = \frac{1}{\sqrt{3}}|\phi_1\rangle + \frac{i}{\sqrt{3}}|\phi_3\rangle$ ... (Given)

Soln:

$|\psi_0\rangle = \frac{1}{\sqrt{2}}|\phi_1\rangle + \frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ — ①

$\langle\psi_0| = \frac{1}{\sqrt{2}}|\phi_1\rangle + -\frac{i}{2}|\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ — ⑪

for normalise $\langle\psi_0|\psi_0\rangle = 1$

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

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

Q3 -> ⓪

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

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

$= 1$

Hence $|\psi_0\rangle$ is normalised

Now;
$|\psi_1\rangle = \frac{1}{\sqrt{3}}|\phi_1\rangle + \frac{i}{\sqrt{3}}|\phi_3\rangle$ ... (from Given) — ①

$\langle\psi_1| = \frac{1}{\sqrt{3}}|\phi_1\rangle + -\frac{i}{\sqrt{3}}|\phi_3\rangle$ — ⑪

$\therefore$ Now: for normalised condition
$\langle\psi_1|\psi_1\rangle = 1$

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

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

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

$$\therefore |\psi_1\rangle \text{ is not normalised}$$

Here; $\langle \psi_0 | = \frac{1}{\sqrt{2}} |\phi_1\rangle \cdot -\frac{i}{2} |\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$ and $\quad \dots$ (from '')

$$|\psi_1\rangle = \frac{1}{\sqrt{3}} |\phi_1\rangle + \frac{i}{\sqrt{3}} |\phi_3\rangle \qquad \dots \text{ (from Given)}$$

$$\therefore \langle \psi_0 | \psi_1 \rangle = \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{3}} - \frac{i}{2} + \frac{i}{\sqrt{3}} \times \frac{1}{2}$$

$$= \frac{1}{\sqrt{6}} - \frac{i}{2} + \frac{i}{2\sqrt{3}}$$

✓

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

Q3 -> (10)

$$\boxed{\langle \psi_0 | \psi_1 \rangle = \frac{1}{\sqrt{6}} - \frac{i}{\sqrt{6}} \left(\frac{\sqrt{3} - 1}{2\sqrt{3}} \right)}$$

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and

$$\langle \psi_1 | = \frac{1}{\sqrt{3}} |\phi_1\rangle - \frac{i}{\sqrt{3}} |\phi_3\rangle \qquad |\phi_0\rangle = \frac{1}{\sqrt{2}} |\phi_2\rangle + \frac{i}{2} |\phi_2\rangle + \frac{1}{2}|\phi_3\rangle$$

$$\therefore \langle \psi_1 | \psi_0 \rangle = \frac{1}{\sqrt{6}} + \frac{i}{2} - \frac{i}{2\sqrt{3}}$$

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

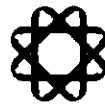$$\boxed{\langle \psi_1 | \phi_0 \rangle = \frac{1}{\sqrt{6}} + i \left(\frac{\sqrt{3} - 1}{2\sqrt{3}} \right)}$$

Space for Marks	Question No.	

(3) $\quad V_{(x)} = \infty \qquad x < 0 \quad$ and $x > a$

$\qquad = -V_0 \qquad 0 < x < \dfrac{a}{2}$

Solution:-

Here $\psi_{(x)} = \sqrt{\dfrac{2}{a}} \sin\left(\dfrac{n\pi x}{a}\right)$

Now 1st order correction is given as

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

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

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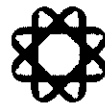
$= \dfrac{2}{a}(-V_0) \int_0^a \sin^2\left(\dfrac{n\pi x}{a}\right) dx$

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

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

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

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

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

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

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

$$= \ -v_0$$

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

(c) $\underline{Soln:}$

$$\hat{H_0} = \begin{bmatrix} E_0+E & 0 \\ 0 & E_0-E \end{bmatrix} \quad \text{and} \quad H' = \begin{bmatrix} 0 & A \\ A & 0 \end{bmatrix}$$

$\underline{Soln:}$

here $\ |H' - E^n\hat{I}| = 0$ Q5 $\rightarrow$ (10)

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

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

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

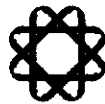$$\therefore \ (E_n^{(1)})^2 - A^2 = 0$$

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

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

1st Order Correction of Energy

for 2nd Order

$$E_n^{(2)} = \frac{\langle \psi_{n(1)}|H'|\psi_2^a\rangle}{E_n^{(1)} - E_m^{(2)}}$$

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

Space for Marks	Question No.	

(5)

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

$$\delta(x) = 0 \qquad \{ x \neq 0 \}$$
$$= \infty \qquad \{ x = 0 \}$$

on changing the scale

$$\delta(x - x_0) = 0 \qquad \{ x \neq x_0 \}$$
$$= \infty \qquad \{ x = 0 \}$$

Here $\delta(x)\,\delta(x - x_0) = 1$

Properties

(i) $\int_{-\infty}^{\infty} \delta(x)\,\delta(x - x_0) = 1$ ✓ Q6 → 10

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(ii) $\int_{-\infty}^{\infty} \delta(x)\,\delta(x - x_0) = f(x_0)$

(iii) $\int_{-\infty}^{\infty} f(x)\,\delta(x - c) = f(c)$
as c lies between a and b

(iii) $\int_{-\infty}^{\infty} f(x)\,\delta(x - c) = 0$
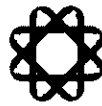as c does not lies in between a and b

(iv) $\delta(ax) = \dfrac{1}{|a|}\delta(x)$

(v) $\delta(-x) = \delta(x)$

(vi) $\dfrac{d}{dx} f(x) = \delta(x)$

(vi) $x\cdot\delta(x) = 0$

(vii) $\delta(a-x)\,\delta(x-b) = \delta(a-b)$

(v⋈) $\delta(a-b) = \delta(b-a)$

(⒃) $\int_{-\infty}^{\infty} \delta(x) = 1$

(𝒸) $\int_{-\infty}^{\infty} f(x)\, \delta(x) = 1$

(c) **Soln:**

$$\hat{x} = \left(\frac{\hbar}{2m\omega}\right)^{1/2} (a + a^+)$$

External perturbation $H' = bx$

Now,

1st order correction to the Energy of the Oscillator is given as

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

$$= \langle \psi_n^{(0)} | b\hat{x} | \psi_n^{(0)} \rangle \quad (a+a^+)$$

$$= \langle \psi_n^{(0)} | \left(\frac{\hbar}{2m\omega}\right)^{1/2} bx | \psi_n^{(0)} \rangle \quad ✓$$
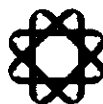
$$= \left(\frac{\hbar}{2m\omega}\right)^{1/2} b \langle \psi_n^{(0)} | (a + a^+) | \psi_n^{(0)} \rangle \qquad (10)$$

$$= \left(\frac{\hbar}{2m\omega}\right)^{1/2} b \langle \psi_n^{(0)} | (a + a^+) | \psi_n^{(0)} \rangle$$

$$E_n^{(1)} = 0 \;//$$

as $(a + a^+) = 0$
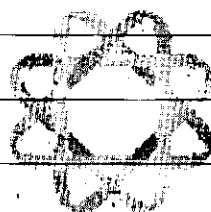
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Q2	10	3	11/29/2025, 9:49:33 AM	jwerry@gmail.com
Q3	0	4	11/29/2025, 9:49:38 AM	jwerry@gmail.com
Q3	10	5	11/29/2025, 9:49:52 AM	jwerry@gmail.com
Q4	10	6	11/29/2025, 9:49:57 AM	jwerry@gmail.com
Q5	10	7	11/29/2025, 9:50:03 AM	jwerry@gmail.com
Q6	10	8	11/29/2025, 9:50:08 AM	jwerry@gmail.com
Q7	10	9	11/29/2025, 9:50:15 AM	jwerry@gmail.com
Q8	10	10	11/29/2025, 9:50:19 AM	jwerry@gmail.com

Total Marks: 80