

Anjuman Islam Janjira Degree College of Science
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Class: -S.Y.B.Sc	Subject: - Physics - III
Semester:- IV	Course code: -USPH403
Exam Event:- Summer 2024 (FH)	Marks: -75
Date:- 08/04/2024	Duration:- 2.30 Hours

Q1. Attempt any Four of the following. (20)

- 1) State and explain the basic postulates of quantum mechanics.
- 2) What is eigen value equation? What are eigen functions and eigen values? Explain it with one example.
- 3) A particle limited to the x axis has unnormalized eigen as

$$\bar{\Psi}(x) = \begin{cases} ax; & 0 < x < 1 \\ 0; & \text{Otherwise} \end{cases}$$

Find the Expectation value of $\langle x \rangle$ of the particle position described by unnormalized wave function.

- 4) The Operator \hat{p}^2 operates on the wave function $\Psi(x, t) = 3x^2 e^{-i\omega t}$ where \hat{P} is the momentum operator, Obtain the result.
- 5) What is well behaved wave function? Discuss the requirement of well-behaved wave function.
- 6) Write the note on analogy between wave function and Schrodinger equation.

Q 2. Attempt any Four of the following. (20)

- 1) Obtain the expression for energy levels of particle moving in an infinitely deep one dimensional potential well and draw the energy level diagram.
- 2) A particle is confined in a cubical box, if $E = \frac{26\pi^2 \hbar^2}{2mL^2}$ calculate the degeneracy of energy state.
- 3) Find minimum energy of electron constrained to move linearly in infinitely high potential box of length 1\AA .
- 4) A particle is moving in one dimensional box of infinite height what is probability of finding the particle in small interval Δx at the centre of box when it is in the energy state next to the least energy state.
- 5) What is free particle? Set up the Schrodinger's equation for free particle.
- 6) Explain the concept of degeneracy of energy state.

Q 3. Attempt any Four of the following. (20)

- 1) Show that for simple harmonic oscillator $\frac{\Delta E}{E_n} = \frac{2}{2n+1}$ What will happen to this if $n \rightarrow \infty$.
- 2) Electrons with energy 1 eV are incident on a barrier of 10 eV and 0.6 nm wide. Calculate the approximate transmission probability.
- 3) Define tunneling effect and write its application.
- 4) Derive the relation of eigen value of the harmonic oscillator, also draw energy level diagram of it.
- 5) A harmonic oscillator consists of a mass of 1 kg on spring and it oscillates with amplitude of 1m and angular frequency is 1 rad/s what is the order of magnitude of quantum no. associated with energy of system?
- 6) State and explain Correspondence principle.

Q4. A) Select correct answer. (Solve any 8 out of 12) (08)

- 1) The expression $|\Psi(x, t)|^2$ stands for _____
 - a) Position
 - b) Normalization
 - c) Position probability density
 - d) time probability density
- 2) The probability density ρ of the given eigen function $\Psi = e^{ix}$ is

- a) 1 b) Zero c) e^x d) e^{-x}
- 3) Which of the following is not the eigen function of the operator $\frac{d^2}{da^2}$ _____.
- a) $\sin x$ b) $\cos x$ c) e^x d) All are correct
- 4) The probability of finding a particle in a distance dx around a point x is_____.
- a) Ψ^* b) Ψ c) $\Psi\Psi^*$ d) $\Psi\Psi^* dx$
- 5) A free particle moving along +ve x axis, whose wave function is represented by_____
- a) $A\sin(kx - wt)$ b) $A\cos(kx - wt)$ c) $Ae^{i(kx-wt)}$ d) $Ae^{\cos(kx-wt)}$
- 6) The energy of a particle trapped in a one dimensional box corresponding to fourth state ($n=4$) is 6 eV. The zero-point energy is_____.
- a) 0.5 eV b) 1 eV c) 2 eV d) 4 eV
- 7) In case of cubical box the first excited state is_____
- a) non-degenerate b) 2- fold degenerate c) 3-fold degenerate d) 6-fold degenerate
- 8) The transmission and reflection coefficients obey which of the following?
- a) $R + T = 1$ b) $R - T = 1$ c) $R = T$ d) $R = 2T$
- 9) When a particle encounters a potential barrier, which phenomenon allows it to pass through the barrier despite lacking the necessary energy?
- a) Reflection b) Absorption c) Tunneling d) Scattering
- 10) Given a harmonic oscillator with a spring constant $k = 10$ N/m, what is the frequency of oscillation in hertz?
- a) 1 Hz b) 2 Hz c) 5 Hz d) 10 Hz
- 11) According to the correspondence principle, what happens to the behavior of a quantum system as its quantum numbers become large?
- a) It becomes classical b) It becomes chaotic c) It becomes random d) It becomes uncertain
- 12) The energy level of the one-dimensional harmonic oscillator is_____.
- a) continuous b) equally spaced c) 2-fold degenerate d) 3-fold degenerate

Q4. B) Answer in one sentence (Solve any three out of five) (03)

- 1) Write 1st postulates of quantum mechanics.
- 2) Define eigenvalue equation.
- 3) What is mean by Free particle in quantum mechanics?
- 4) Define Degeneracy of energy state.
- 5) Draw the eigen function of harmonic oscillator in first excited state.

Q4. C) Fill in the Blanks (Solve any four out of six) (04)

- 1) For Stationary Define Degeneracy of energy State the _____ is function of time.
- 2) The Energy of the particle is proportional to _____ .
- 3) The probability of finding the particle between $x = 0$ and $x = 1$ of the given eigen function $\psi = x$ is_____
- 4) In the case of one-dimensional infinite deep potential well, the principle quantum number n cannot have the value_____
- 5) α particle are emitted from the nucleus by_____ effect.
- 6) The energy of a one-dimensional harmonic oscillator in the first excited state is_____.