M.Sc. F.Y. (Physics) (CBCS Pattern) Sem-II

PSCPHYT05 - Paper-V (Core-V) : Quantum Mechanics-I

P. Pages : 2 **GUG/W/22/11220**

Time : Three Hours Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Assume suitable data wherever necessary.
3. Illustrate your answers wherever necessary with the help of neat sketches.

Either:

1. a) What is wave packet? How it represent analytically and diagrammatically prove that velocity of a particle and velocity of corresponding wave pocket are same. **8**

b) Derive an equation of continuity for probability. Evaluate probability current of wave function. **8**

$$\psi = \frac{A}{r} e^{ikr}$$

OR

e) i) What is stationary state. Show that probability current density is constant in time. **6**

ii) For one dimensional wave function of the form $\psi(x,t) = A\exp\left[i\,\phi(x,t)\right]$, derive eigen values for above function. **4**

f) Derive an expression for time dependent Schrodinger wave equation for particle. **6**

Either:

2 a) Define Hermitian Operator. **8**

Show that : i) He eigen value of Hermitian operator are real.

ii) Eigen function belonging to different eigenvalue are orthogonal.

b) Explain the different postulate of quantum medonics. **8**

OR

e) i) Define the uncertainty (ΔA) in the measurement of a dynamical variable state & explain the general uncertainty principle. **6**

ii) The wave function of a particle is **6**

$$\psi(x) = N\exp\left(\frac{-x^2}{2a}\right)$$

find $\Delta x \,\&\, \Delta Px$. Hence evaluate the uncertainty product $(\Delta x).(\Delta Px)$

f) Derive an Heisenberg eigen equation of a motion. **4**

Either:

3. a) Obtain the eigen value for L^2 & expression for L^2 in spherical polar co-ordinates. **8**

b) Derive the general solution for one dim. Linear harmonic oscillator. **8**

OR

e) i) What is parity operator. **8**

ii) Explain the role of L^2 operator in central force problem.

f) Write the Schrodinger equation and the form of wave function in the different region of square well with finite depth. **8**

Either:

4. a) i) Explain representation of angular momenta. Derive matrices for J_x, J_y, J_+ and J_- for $J = 1$. **10**

ii) Derive matrices for the operator J^2, J_x, J_y, J_z for $j = 3/2$.

b) Solve the following. **6**

i) $\left[L_x^2, L_y\right]$

ii) $\left[L_y, L_z^2\right]$

iii) $\left[L_y, L_x\right]$

OR

e) Obtain the Clebsch – Gordan coefficient for the system having $j = 1 \& j_z = 1/2$. **8**

f) Evaluate the following commutators.

i) $\left[J_z^2, J_y\right], \left[J_x^2, J_y\right], \left[J^2, J_z\right]$ **4**

ii) What is meant by raising & lowering operators. Solve $\langle n | a a^+ a a^+ | n \rangle$ and $\langle n | a^+ a a a | n \rangle$. **4**

5. Attempt all the followings.

a) The wave function $\psi(x) = A \sin(n \pi x / L)$ normalize the wave function & evaluate the expectation value of its momentum. **4**

b) Prove the eigen value of A & A' are same. **4**

c) Show that the component of angular momentum operator do not commutes among themselves. **4**

d) Prove that : **4**

i) $\left[\sigma_x, \sigma_y\right] = 2i\sigma_z$

ii) $\sigma_x \sigma_y \sigma_z = i$

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