PHYSICS PAPER–C

(Quantum Physics)

Time Allowed : 3 Hours **Maximum Marks : 22**

Note : (1) Attempt **five** questions in all, selecting at least **two** questions each from Unit–I and Unit–II. Question No. 7 of Unit–III is compulsory.

(2) Use of non-programmable calculator is allowed.

UNIT—I

1. (a) Define Uncertainty principle. Give any two applications of this principle. 2

(b) A particle is described by a wave function $\Psi(x) = \frac{1+ix}{1+ix^2}$, prove that average value of position of the particle is zero. 2

2. (a) Show that $m\frac{d}{dt}\langle x\rangle = \langle P_x\rangle$ [Ehrenfest theorem]. 2

(b) Show that $e^{i\phi}$ is an eigen function of z component of angular momentum operator. 2

3. (a) Show that if Ψ_1 and Ψ_2 are the solutions of time independent Schrodinger equation, then the function $\Psi = C_1\Psi_1 + C_2\Psi_2$ is also a solution for any constants C_1 and C_2. 2

(b) Show that group velocity V_g can be obtained from phase velocity V_p by the relation :

$V_g = V_p - \lambda\frac{dV_p}{d\lambda}$, λ is wavelength. 2

UNIT—II

4. What do you mean by Tunnel effect ? A particle travelling with Energy E along x-axis faces a potential barrier defined as :

$$V(x) = \begin{cases} 0 & \text{for} \quad x < 0 \\ V_0 & \text{for} \quad 0 < x < a \\ 0 & \text{for} \quad x > a \end{cases}$$

Derive an expression for transmission coefficient of the barrier. 4

5. (a) The ground state wave function for hydrogen atom is $\Psi = \frac{1}{\sqrt{\pi a_0^3}} e^{-\frac{r}{a_0}}$ find the value of average distance of the electron from the nucleus. 2

(b) Show that the state of a hydrogen atom for a given value of η is n^2 fold degenerate. 2

6. (a) For a free particle trapped in a one dimensional box, show the plots of normalised wave function and probability density. 2

(b) What are nodes and antinodes ? Where do they occur ? Explain in terms of probability density. [Related to part (a)]. 2

UNIT—III

7. Attempt any six parts :

(a) Show that operators p_x and p_y commute.

(b) What is the zero point energy of harmonic oscillator ?

(c) Explain the term degeneracy.

(d) What are the orthonormal functions ?

(e) Show that sum of reflection and transmission coefficients for a potential barrier for $E > V_o$ is unity, E is total energy. V_0 is height of barrier.

(f) Show that momentum operator is a Hermitian operator.

(g) Define Gaussian wave packets. 1×6=6