QUANTUM MECHANICS–I

Paper - III Semester - III

Time Allowed : Three Hours]   [Maximum Marks : 35

Note : The candidates are required to attempt *two* questions each from Section A and B carrying 8 marks each and the entire Section C consisting of 8 short answer type questions carrying 1 marks.

Section : A

1. Derive time dependent Schrodinger equation and from it obtain time independent Schrodinger equation.   8

2. State Heisenberg's Uncertainty Principle. Derive an expression for the uncertainty in position and momentum measurement.   8

3. Derive a relation for wave function of a Gaussian wave packet and plot it graphically explaining its properties.   8
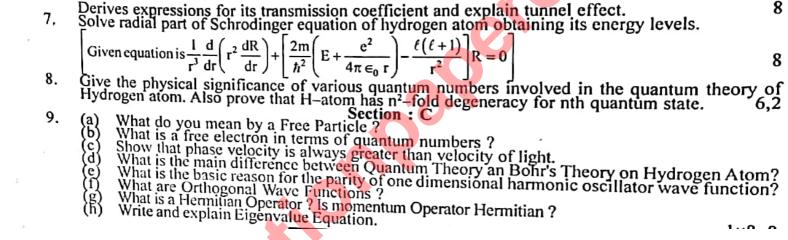
4. (a) Show that if they phase velocity is constant then the group velocity is equal to phase velocity. 4
    (b) One dimensional wave function is given by :

    $$\psi(x) = A \sin\left(\frac{\pi x}{a}\right) \text{ for } 0 < x < a$$

    $$\psi(x) = 0 \quad \text{outside}$$

    Normalize this wave function.   4

Section : B

5. Consider a particle incident on a potential stpe of height V_0 with energy $E < V_0$. Calculate coefficient of reflection.   8

6. A particle travelling with energy E along x–axis faces a potential barries as :

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

Derives expressions for its transmission coefficient and explain tunnel effect. 8

7. Solve radial part of Schrodinger equation of hydrogen atom obtaining its energy levels.

$$\left[\text{Given equation is} \ \frac{1}{r^3} \frac{d}{dr} \left(r^2 \frac{dR}{dr} \right) + \left[\frac{2m}{\hbar^2} \left(E + \frac{e^2}{4\pi \epsilon_0 \ r} \right) - \frac{\ell(\ell+1)}{r^2} \right] R = 0 \right]$$

8

8. Give the physical significance of various quantum numbers involved in the quantum theory of Hydrogen atom. Also prove that H–atom has n^2–fold degeneracy for nth quantum state. 6,2

Section : C

9. (a) What do you mean by a Free Particle ?
(b) What is a free electron in terms of quantum numbers ?
(c) Show that phase velocity is always greater than velocity of light.
(d) What is the main difference between Quantum Theory an Bohr's Theory on Hydrogen Atom?
(e) What is the basic reason for the parity of one dimensional harmonic oscillator wave function?
(f) What are Orthogonal Wave Functions ?
(g) What is a Hermitian Operator ? Is momentum Operator Hermitian ?
(h) Write and explain Eigenvalue Equation.

1×8 8