M.Sc. (Physics) (NEP Pattern) Semester-IV

04MSCPH3.2 - Paper-III : Advanced Quantum Mechanics

P. Pages : 2 **GUG/S/25/16378**

Time : Three Hours * 3 9 7 2 * Max. Marks : 80

Notes : 1. All questions are compulsory.
2. Draw neat labelled diagram wherever necessary.

Either:

1. a) Explain the application of perturbation theory of ground state energy. **8**

b) What is mean by barrier penetration? Explain use of W.K.B. method in barrier penetration. **8**

OR

c) Give first order perturbation theory of non-degenerate system and find the expression of energy and wave function. **8**

d) Estimate the ground state energy of a one-dimensional harmonic oscillator of mass m and angular frequency ω using a Gaussian Trial Function $\phi(x) = Ae^{-ax^2}$. **8**

Either:

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

b) What are the Pauli spin matrices? show that **8**

$[\sigma_x, \sigma_y] = 2i\ \sigma_z$

$[\sigma_y, \sigma_z] = 2i\ \sigma_x$

$[\sigma_z, \sigma_x] = 2i\ \sigma_y$

OR

c) What are Clebsch-Gordan coefficient? Explain its significance. **8**

d) Solve the following. **8**

i) $[L_x^2, L_y]$ ii) $[L_y, L_z^2]$

iii) $[L_y, L_x]$ iv) $[L^2, L_x]$

Either:

3. a) Derive Klein-Gordan equation for a free particle. **8**

b) Explain spin-orbit interaction for Dirac's particles. **8**

OR

c) Derive Dirac Hamiltonian for the relativistic particle. What are the properties of α and β? **8**

d) Prove that, a Dirac electron has a magnetic moment $\mu = \frac{e\hbar\sigma}{2mC}$ **8**

Either:

4. a) Explain Born-Oppenheimer approximation in scattering and discuss its validity. **8**

b) Discuss scattering cross-section in Laboratory and Centre of mass system. **8**

OR

c) Explain scattering theory of quantum particle using Particle wave method. **8**

d) Use born approximation to calculate the differential cross section for scattering by the central potential $V(r) = \frac{\alpha}{r^2}$, where α is constant. **8**

5. Attempt all of the followings.

a) If unperturbed Hamiltonian of a system is $H_0 = \frac{P^2}{2m} + \frac{1}{2} m \omega^2 x^2$, If a small perturbation $V' = \lambda x$ for $x > 0$ acts on the system evaluate the first order correction to the ground state energy. **4**

b) Solve the following. **4**

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

ii) $\left[L_z, L_x\right]$

c) Give the physical significance of negative energy states. **4**

d) Obtain an expression for the phase shift δ_0 for s-wave scattering by the potential $V(r) = \infty$ for $0 \le r \le a$ & $V(r) = 0$ for $r > 0$. **4**

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