GALGOTIAS UNIVERSITY

ADMISSION NUMBER												

School of Basic Sciences

Master of Science in Physics

Mid Term Examination - May 2024

Duration : 90 Minutes
Max Marks : 50

Sem II - C1PO202T - Quantum Mechanics-II

General Instructions
Answer to the specific question asked
Draw neat, labelled diagrams wherever necessary
Approved data hand books are allowed subject to verification by the Invigilator

1) Interprete the properties of sphrical harmonics. K2 (2)

2) Explain the Perturbation theory. K1 (3)

3) Explain the properties of spherical harmonics. K2 (4)

4) Calculate the first order correction to the ground state energy of an harmonic oscillator of K2 (6)

mass m and angular frequency ω subjected to a potential $V(x) = 1/2\ m\omega^2 x^2 + bx^4$, where b is a parameter independent of x. The ground state wave function is

$$\psi_0^0 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} \exp\left(-\frac{m\omega x^2}{2\hbar}\right)$$

5) Build the splitting energy level diagram due to L-S coupling in weak magnetic filed. K3 (6)

6) Obtain the first oreder correction in energy and wavefunction for $V = bx^3$ K3 (9)

7) K4 (8)

Calculate the differential cross section in the first Born approximation for the scattering between two identical particles having spin 1, mass m, and interacting through a potential $V(r) = V_0 e^{-\alpha r}$.

8)

K4 (12)

Using first-order perturbation theory, calculate the energy of the nth excited state for a spinless particle of mass m moving in an infinite potential well of length $2L$, with walls at $x = 0$ and $x = 2L$:

$$V(x) = \begin{cases} 0, & 0 \le x \le 2L, \\ \infty, & \text{otherwise,} \end{cases}$$

which is modified at the bottom by the following two perturbations:

(a) $V_p(x) = \lambda V_0 \sin(\pi x/2L)$; (b) $V_p(x) = \lambda V_0 \delta(x - L)$, where $\lambda \ll 1$.

OR

K4 (12)

Consider a system whose Hamiltonian is given by $\hat{H} = E_0 \begin{pmatrix} 1+\lambda & 0 & 0 & 0 \\ 0 & 8 & 0 & 0 \\ 0 & 0 & 3 & -2\lambda \\ 0 & 0 & -2\lambda & 7 \end{pmatrix}$,

where $\lambda \ll 1$.

(a) By decomposing this Hamiltonian into $\hat{H} = \hat{H}_0 + \hat{H}_p$, find the eigenvalues and eigenstates of the unperturbed Hamiltonian $\hat{H}_0$.

(b) Diagonalize $\hat{H}$ to find the exact eigenvalues of $\hat{H}$; expand each eigenvalue to the second power of λ.