LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION – **PHYSICS**

SECOND SEMESTER – **APRIL 2022**

PPH 2503 – QUANTUM MECHANICS - I

Date: 20-06-2022 Dept. No. Max. : 100 Marks

Time: 09:00 AM - 12:00 NOON

PART – A

Q. No Answer **ALL** Questions **(10 x 2 = 20 Marks)**

1 If the wave function of a particle in a state is given by $\psi(x) = \left(\frac{1}{\pi}\right)^{1/4} e^{(-\frac{x^2}{2})}$ in the limit $-\infty \leq x \leq +\infty$, then find $< x^2 >$

2 With example, explain linear operators.

3 If $|\psi_1> = \frac{1}{\sqrt{\pi}} \sin x$ ***and*** $|\psi_2> = \frac{1}{\sqrt{\pi}} \sin 2x$, then show that they form an ortho-normal basis set in the limit $-\pi \leq x \leq \pi$.

4 Represent $|\psi>$, $<\psi|\psi>$ and $|\psi><\psi|$ in terms of the expansion coefficients.

5 Write down the Hamiltonian of the helium atom.

6 Evaluate $< 1|x^4|1 >$ for a one dimensional harmonic oscillator by expressing x^4 in terms of ladder operators.

7 Show that $J_+ \psi_{jm}$ is an eigen function of J_z with eigen value $(m+1)\hbar$

8 Write down the complete eigen kets before and after addition of angular momentum $j_1 = 1$ & $j_2 = 1$.

9 Define differential scattering cross section and total cross section.

10 What is Ramsaur-Townsend effect?

PART – B

Answer any **FOUR** Questions **(4 x 7.5 = 30 Marks)**

11 Derive the equations of motion in the Schrodinger picture.

12 Establish any four properties of operators that remain invariant under unitary transformation.

13 Evaluate the commutation relations of J_+ with J^2, J_z, J_x, J_y.

14 Describe the Greens' function technique and hence obtain an expression for differential scattering cross-section.

15 State and prove the general variational principle for the ground state.

16 Show that (i) the eigenvalues of a Hermitian operator are real. (3.5)

(ii) Any two eigenfunctions of a Hermitian operator belonging to different eigenvalues are orthogonal. (4)

PART – C

Answer any **FOUR** Questions **(4 x 12.5 = 50 Marks)**

17 Solve for the eigen values of the harmonic oscillator using the Heisenberg matrix method.

18 State and prove any five properties of Pauli spin matrices.

19 Discuss Stark effect with reference to n = 2 state of the hydrogen atom.

20 From phase shift analysis of scattering by an attractive square well potential, derive Breit-Wigner formula for resonance scattering.

21 Establish the general uncertainty relation between any two dynamical variables.

22 Explain quantum mechanical tunneling across a potential barrier.

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