LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc.DEGREE EXAMINATION – **PHYSICS**

SECONDSEMESTER – APRIL 2018

17/16PPH2MC03/PH2816 - QUANTUM MECHANICS - I

Date: 21-04-2018 Dept. No. Max. : 100 Marks
Time: 01:00-04:00

PART A

Answer **ALL** the Questions (10 x 2 = 20)

1. State any two postulates of quantum mechanics.
2. If operators **A** and **B** are Hermitian, show that i[**A**,**B**] is Hermitian.
3. If linear operators **A** and**A**' are related through unitary transformation, show that **A** and **A**' are Hermitian.
4. Show that the expectation values remain unchanged in an unitary transformation.
5. Prove that $(a\, a^{\dagger}a^{\dagger}a^{\dagger})|0> = 0$, where a and $a^{\dagger}$ are the lowering and raising operators respectively.
6. Write down the Hamiltonian of the helium atom.
7. Establish the relation $[J_+, J_-] = 2\hbar J_z$
8. If $j_1 = 1$ and $j_2 = 1$, what are the allowed values of resultant **J** and **m**?
9. What is Ramsaur-Townsend effect?
10. Explain resonance scattering.

PART B

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

11. Derive the equations of motion in the Heisenberg picture.
12. Show that momentum operator $\vec{p}$ in momentum representation.
13. Explain how degeneracy is lifted in a doubly degenerate state using time independent perturbation theory.
14. Assuming the operator equation for ladder operators show that

    $<j'm'|J_+|jm>=[j(j+1)-m(m+1)]^{1/2}\hbar\boldsymbol{\delta}_{j',j}\,\boldsymbol{\delta}_{m',m+1}$ and

    $<j'm'|J_-|jm>=[j(j+1)-m(m-1)]^{1/2}\hbar\boldsymbol{\delta}_{j',j}\,\boldsymbol{\delta}_{m',m-1}$
15. Explain the validity of Born's approximation for obtaining an expression for scattering cross-section.
16. Show that the differential scattering cross section is square of the scattering amplitude.

PART C

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

17. Solve for the eigenvalues of the radial part of the Schroedinger equation for the hydrogen atom.

18. Solve graphically the eigenvalue problem of particle in a square-well potential with finite walls.
19. Using the Heisenberg matrix method, obtain the eigen values of the harmonic oscillator.
20. Explain the formation of the hydrogen molecule using variational method.
21. Obtain the C.G. coefficients for addition of angular momenta $j_1=1$ and $j_2=1/2$.
22. For scattering by an attractive square well potential, derive general expression for phase shifts.

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