LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

SECONDSEMESTER – APRIL 2017

16PPH2MC03/ PH 2816 - QUANTUM MECHANICS - I

Date: 24-04-2017 Dept. No. Max. : 100 Marks

01:00-04:00

SECTION –A

Answer **all** the questions. (10 x 2 = 20 Marks)

1. Establish the fact that $i\frac{d}{dx}$ is a Hermitian operator.
2. If $[\mathbf{a},\mathbf{a}^\dagger] = 1$ and that $H = (\mathbf{a}\mathbf{a}^\dagger + \mathbf{a}^\dagger\mathbf{a})\frac{\hbar\omega}{2}$, then show that $[a, H] = \hbar\omega\mathbf{a}$
3. Prove that if A is hermitian, then $U = \frac{A+iI}{A-iI}$ is unitary.
4. For a continuous basis set $|w_\alpha\rangle$, represent $\langle\varphi|\psi\rangle$ and $\langle\varphi|F|\psi\rangle$ in terms of the expansion coefficients.
5. Show that the first order correction to the energy is the average value of the perturbation over the unperturbed states of the system.
6. Use the trial wave function $\psi = \exp(-kr)$ to find the ground state of a hydrogen –like atom.
7. Show that $J_-\psi_{jm}$ is an eigen function of J_z with eigen value $(m-1)\hbar$
8. Establish the commutation relation $[J_+, J_-] = 2\hbar J_z$
9. Explain resonance scattering.
10. Outline the Green's function technique for scattering.

SECTION –B

Answer **any four** questions. **(4 x 7.5 = 30 marks)**

11. Starting from coordinate representation, obtain the operator form for momentum in the momentum representation.
12. State and prove any five properties of Pauli spin matrices.
13. Express the asymptotic solution to the Schrodinger equation of scattering by a central potential as the sum of phase shifted spherical waves.
14. Relate the differential scattering cross-section in the laboratory and center of mass coordinate system.
15. Assuming that $\langle j_1 j_2 | j_1+j_2, j_1+j_2\rangle = +1$, then show that $\langle j_1, j_2-1 | j_1+j_2-1, j_1+j_2-1\rangle = \sqrt{\left(\frac{j_1}{j_1+j_2}\right)}$ and $\langle j_1-1, j_2 | j_1+j_2-1, j_1+j_2-1\rangle = -\sqrt{\left(\frac{j_2}{j_1+j_2}\right)}$
16. Obtain first order correction to the energy of an anharmonic oscillator for a perturbation of the form bx^4.

SECTION –C

Answer **any four** questions. **(4 x 12.5 = 50 marks)**

17. Obtain the eigenvalues of the radial part of the Schroedinger equation for the hydrogen atom.
18. Solve graphically the eigenvalue spectrum of a particle in a square-well potential with finite walls'
19. Using the Heisenberg matrix method,solve for the eigen values of the 1D harmonic oscillator.
20. Discuss stark effect with reference to n=2 state of the hydrogen atom using time independent perturbation technique.
21. Derive an expression for first Born's approximation and use it to explain scattering by a screened coulomb potential
22. Using Bra and Ket notation, obtain the eigenvalue spectrum of J^2 and J_z.

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