LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

M.Sc. DEGREE EXAMINATION - **PHYSICS**

SECOND SEMESTER – **APRIL 2013**

PH 2816 - QUANTUM MECHANICS - I

Date : 02/05/2013 Dept. No. Max. : 100 Marks
Time : 9:00 - 12:00

PART A

Answer **ALL** questions (10 x 2 = 20)

1. If the wave function for a system is an eigen function of the operator associated with the observable A, show that $<A^n> = <A>^n$
2. When do you say two functions are orthonormal?
3. Represent a three dimensional wave function in matrix form.
4. What is a unitary transformation?
5. Show that the following transformation matrix is unitary $\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{i}{\sqrt{2}} & \frac{-i}{\sqrt{2}} \end{pmatrix}$
6. What is Rayleigh ratio?
7. Explain briefly the basic principle of time-independent perturbation theory.
8. What are ladder operators? Why are they called so?
9. What are selection rules?
10. Explain optical theorem with reference to scattering cross section.

PART B

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

11. Define a linear operator. A and B are two operators defined by $A\Psi(x) = \Psi(x) + x$ and $B\Psi(x) = \frac{d\Psi}{dx} + 2\Psi(x)$ check for their linearity. (2.5 +5)
12. Prove that the fundamental commutation relation $[x, p_x] = i\hbar$ remains unchanged under unitary transformation.
13. Explain the stark effect in a plane rotator.
14. If $H = \frac{p2}{2\mu +} + \frac{1}{2}\mu\omega^2 x^2$ then show that
    a) $xH - Hx = \frac{i\hbar p}{\mu}$ and b) $pH - Hp = -i\hbar\mu\omega^2 x$ (4+3.5)
15. A beam of particles is incident normally on a thin metal foil of thickness t. If N_0 is the number of nuclei per unit volume of the foil, show that the fraction of incident particles scattered in the direction (θ, φ) is $\sigma(\theta, \varphi)\, N_0 d\Omega$ where dΩ is the small solid angle in the direction (θ, φ).

PART C

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

16. (a) A particle of mass m moves in a three dimensional box of sides a, b, c. If the potential is zero inside and infinity outside the box, find the energy eigen values and eigen functions. (b) If the box is a cubical one of side a, derive expression for energy eigen values and eigen functions. (9 + 3.5)
17. Prove that the matrix representation of an operator with respect to its own eigen functions is diagonal and the matrix elements are the eigen values of the operator.
18. Develop the time independent perturbation theory up to the second order.
19. (a) Interpret the concept of identical particles. Formulate the Pauli's principle on the basis of the above concept. (b) Prove $\boldsymbol{\sigma_x \sigma_y \sigma_z = i}$ and $\boldsymbol{\sigma^2 = 3}$ (8.5 + 4)
20. Discuss the Born-approximation method of scattering theory and obtain an expression for the scattering amplitude.

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