LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

SECOND SEMESTER – **APRIL 2013**

PH 2811/2808 - QUANTUM MECHANICS

Date : 29/04/2013 Dept. No. Max. : 100 Marks

Time : 9:00 - 12:00

PART A

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

1. Prove [[A,B], C]+[[B,C], A]+[[C, A], B] = 0
2. Determine the eigenvalues of a parity operator.
3. State any two postulates of quantum mechanics.
4. Prove that the square of the angular momentum commutes with its components.
5. What is meant by degeneracy of an energy level?
6. What is an orthonormal basis?
7. With an example explain simultaneous eigenfunctions.
8. If A and B are two operators, then show that $[A^{-1}[A,B]] = 2B$.
9. Explain variation principle.
10. Outline the basic principle of time-independent perturbation theory.

PART B

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

11. Show that the eigen values of a Hermitian operator are real. (b) If A and B are Hermitian operators, show that (AB + BA) is Hermitian and (AB – BA) is not Hermitian. Prove that the operators $\boldsymbol{i}\frac{\boldsymbol{d}}{\boldsymbol{dx}}$ *and* $\frac{\boldsymbol{d^2}}{\boldsymbol{dx^2}}$ are Hermitian. (2.5 x 3)
12. Obtain the normalized wave function for a particle trapped in the potential V(x) = 0 for 0 < x < a and V(x) = ∞ otherwise.
13. (a) With an example explain linear operator (b) 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)
14. If the components of arbitrary vectors **A** and **B** commute with those of **σ**. Show that (**σ**.**A**) (**σ**.**B**) = **A**.**B** + i **σ**.(**A**x**B**)
15. Calculate the first-order correction to the ground state energy of an anharmonic oscillator of mass m and angular frequency ω subjected to a potential.

$$\mathbf{V(x)} = \frac{1}{2}m\omega^2x^2 + b\,x^4$$ where b is parameter independent of x.

PART C

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

16. (i) Outline the probability interpretation of the wave function. (ii) An electron has a speed of 500 m/s with an accuracy of 0.004%, calculate the certainty with which we can locate the position of the electron. iii) Can we measure the kinetic and potential energies of a particle simultaneously with arbitrary precision? (2.5 + 5 +5)
17. **(a)** Obtain the energy eigen values and eigen functions of a particle trapped in the

potential V(x) = 0 for –a < x < a and V(x) = ∞ for $|x|$ > a. **(b)** An electron in one dimensional infinite potential well goes from n = 4 to n =2, the frequency of the emitted photon is 3.43 x 10^{14} Hz. Find the width of the path.

(8 + 4.5)

18. (i) What is symmetry transformation? Prove that a symmetry transformation conserves probabilities. (ii) Prove $\boldsymbol{\sigma_x \sigma_y \sigma_z = i}$ and $\boldsymbol{\sigma^2 = 3}$

    (7.5 +5)

19. Consider two noninteracting electrons described by the Hamiltonian,

    $H = \frac{p_1^2}{2m} + \frac{p_2^2}{2m} + V(x_1) + V(x_2); V(x) = 0 \; for \; 0 < x < a \; ; V(x) = \infty \; for \; x > a.$

    If both the electrons are in the same spin state what is the lowest energy and Eigen function of the two electron system?

20. Explain the effect of an electric field on the energy levels of a plane rotator.

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