Reg. No..... Name..... 15P2019

M. Sc. DEGREE END SEMESTER EXAMINATION APRIL 2017

SEMESTER **– 2: PHYSICS**

COURSE: **15P2PHYT06; QUANTUM MECHANICS - I**

(For Supplementary - 2015 Admission)

Time: Three Hours Max. Marks: 75

PART A

Answer **all** questions. Each question carries 1 Mark

1. The probability that x lies between x and x+dx is P(x)dx =a e^{-ax} dx , where a<x<∞ and a>0. Then the probability that x lies between x_1 & x_2 ($x_2 > x_1$) is
   a) $(e^{-ax_1} - e^{-ax_2})$
   b) a $(e^{-ax_1} - e^{-ax_2})$
   c) e^{-ax_2} $(e^{-ax_1} - e^{-ax_2})$
   d) $\frac{a}{2}$ $(e^{-2ax_1} - e^{-2ax_2})$
2. Given a wavefunction $\varphi(x) = \frac{N}{x^2+\square^2}$, where δ is a real constant. The normalization constant N is
   a) $\sqrt{\frac{\square^3}{\square}}$ b) $\sqrt{\frac{2^3}{\square}}$ c) $\sqrt{\frac{2}{\square^3}}$ d) $\sqrt{\frac{\square}{\square^3}}$
3. For a harmonic oscillator with H the Hamiltonian operator and $a^\dagger$ the creation operator, $[\, a^\dagger, H\,]$ is
   a) ħωa b) $\hbar\omega a^\dagger$ c) – ħωa d) – $\hbar\omega a^\dagger$
4. L is angular momentum operator. Then L X L is
   a) Zero b) iħL c) L_x d) L_y
5. Electrons have half integral spin and they obey
   a) B-E statistics
   b) F-D statistics
   c) M-B statistics
   d) Neither of the above

(1 x 5 = 5)

PART B

Answer **any five** questions, each question carries 2 Marks

6. Show that the eigenvalues of a hermitian operator are real.
7. Explain the time-energy uncertainty relation
8. Why should time evolution operator be unitary
9. State and explain Ehrenfest's theorem
10. What are Pauli spin matrices
11. What are Clebsch-Gordon coefficients
12. Write down the condition under which we can apply the WKB approximation.
13. Degeneracy is removed by perturbation. Explain.

(2 x 5 = 10)

PART C

Answer **any three** questions. Each question carries 4 Marks

14. The expectation value of an antiHermitian operator is purely imaginary. Prove.
15. Distinguish between Schrödinger and Heisenberg picture.
16. Evaluate a) $[J_{+}, J_{-}]$ b) $[J_z, J_{+}]$
17. What are connection formulae ? How they are used in barrier penetration problem.
18. Explain Zeeman effect using first order perturbation theory.

(4 x 3 =12)

PART D

Answer **all** questions. Each question carries 12 Marks

19. a) Calculate the expectation values of the operators x, x^2, p and p^2 for a Gaussian wave packet.

OR

b) State and prove the properties of (1) Hermitian operator (2) Unitary operator

20. a) Explain "time evolution operator". Derive an expression for the operator

OR

b) Obtain the expression for energy levels of a harmonic oscillator

21. a) Calculate the angular momentum matrices for J^2 , J_z, J_x and J_y

OR

b) Derive the fundamental commutation relations of angular momentum.

22. a) Discuss normal Zeeman effect in hydrogen atom based on degenerate perturbation theory.

OR

b) Using stationary state perturbation theory, discuss the anharmonic oscillator problem in detail.

(12 x 4 = 48)

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