K24P 0866

Reg. No. : .....

Name : .....

Second Semester M.Sc. Degree (CBSS – Supple. (One Time Mercy Chance)/Imp.) Examination, April 2024
(2014 to 2022 Admissions)
PHYSICS
PHY 2C06 : Quantum Mechanics – I

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions (Either **a** or **b**).

1. a) Obtain the energy eigen values of linear harmonic oscillator by applying Schrödinger picture.

   OR

   b) Discuss addition of angular momentum in quantum mechanics and Clebsch-Gordon coefficients.

2. a) Discuss symmetry transformations and list out its properties. Prove that the total energy of the system is conserved if the system is invariant under translation in time.

   OR

   b) Give the time independent perturbation theory and apply it to find the energy of anharmonic oscillator with quadratic term $H' = bx^4$. **(2×12=24)**

SECTION – B

Answer **any four** questions (**One** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).

3. a) Define basis of a vector space.
   b) Discuss Hilbert space and its properties.
   c) Evaluate the commutator :
      i) $\left[x, P_x^2\right]$ ii) [x, [x, H]].

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4. a) Define expectation value of an observable.
   b) Show that the expectation value of a Hermitian operator is real.
   c) Obtain the equation of motion for an operator in Heisenberg picture.

5. a) Define orbital angular momentum operator L.
   b) Prove that $L_+ L_- = L^2 - L_z^2 + \hbar L_z$, where L is angular momentum operator.
   c) Obtain matrices for the angular momentum operators J^2, J_z, for J = 1.

6. a) Define Stark effect.
   b) Prove that the ground state of hydrogen atom will not show a first order Stark effect.
   c) Using variational method, obtain the ground state energy of one-dimensional harmonic oscillator of mass m and angular frequency ω. Use $A \exp(-ax^2)$ as trial function.

7. a) Define zero-point energy of a harmonic oscillator.
   b) Explain energy – time uncertainty relationship.
   c) Prove that zero-point energy of a harmonic is a consequence of uncertainty principle.

8. a) What is parity operation ?
   b) Prove that the eigen values of parity operator are –1 or +1.
   c) Show that the trace of an operator does not depend on the basis in which it is expressed. **(4×9=36)**

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