Total No. of Questions :7]

SEAT No. :

P1920

[Total No. of Pages :2

[4922]-14
M.Sc.
PHYSICS
PHYUT-504: Quantum Mechanics - I
(2008 Pattern) (Semester - I) (Old Course)

Time : 3 Hours] *[Max. Marks :80*

Instructions to the candidates:

1) ***Question No.1 is compulsory. Attempt any four from the remaining.***
2) ***Draw neat diagrams wherever necessary.***
3) ***Figures to the right indicate full marks.***
4) ***Use of logarithmic table and calculator is allowed.***

Q1) Attempt any four of the following: **[16]**

a) Show that momentum operator is Hermitian.

b) Evaluate the commutator $[L^2, L_z]$.

c) For Pauli's matrices, prove that

i) $[\sigma x, \sigma y] = 2i\, \sigma z$

ii) $\sigma x \sigma y\, \sigma z = i$

d) Show that for any arbitrary operator $A, \langle A^+A \rangle \geq 0$.

e) What are ladder operators? Why are they called so?

f) Show that if two operators commute with each other then they have common set of eigen functions.

Q2) a) Using the abstract operator method, obtain the eigen value spectrum of simple harmonic oscillator. **[8]**

b) What are observables? Show that **[8]**

i) Eigen functions belonging to continuous eigenvalues are of infinite norm.

ii) Eigen functions belonging to discrete eigen values are normalizable.

P.T.O.

Q3) a) What are Dirac's bra and ket vectors? With respect to these vectors define Hilbert space. Write expressions for the norm and scalar product in this space and define the basis of Hilbert space. **[8]**

b) Describe Heisenberg picture and show that

$$\frac{d}{dt}A_H = \frac{i}{\hbar}[H, A_H] + \frac{\partial A_H}{\partial t}$$ **[8]**

Q4) a) Explain completeness property and prove the closure relation. **[8]**

b) Define projection operator. Show that the sum of all projection operators leaves any state vector $|\psi\rangle$ unchanged. **[8]**

Q5) a) Obtain the matrix of Clebsch-Gorden coefficients for a system of two non-interacting particles with angular momenta $j_1 = 1/2$ and $j_2 = 1/2$. **[8]**

b) State fundamental postulates of quantum Mechanics. **[8]**

Q6) a) Obtain eigen values of L^2 and L_z using L_+ and L_- operators. **[8]**

b) Describe change of basis by using unitary transformations. **[8]**

Q7) a) Using Dirac notations, prove that eigenvalues of Hermitian operator are real. **[4]**

b) For any Hermitian operator $\hat{A}$, show that $e^{i\alpha A}$ is unitary, where α is real number. **[4]**

c) Show that $(A B)^+ = B^+ A^+$. **[4]**

d) What do you understand by 'spin of an electron'? **[4]**

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