

Roll No.

72603

**M.Sc. Physics 1st Sem.
Examination-December, 2014**

Quantum Mechanics-I

Paper : III

Time : 3 hours

Max. Marks : 80

Before answering the questions, candidates should ensure that they have been supplied the correct and complete question paper. No complaint in this regard will be entertained after the examination.

Note : Attempt **five** questions in all, selecting **one** question from each Unit. Question No. 1 is **compulsory**.

1. (a) Check the Hermiticity of operators :

(i) $i(A + A^+)$

(ii) $i(A - A^+)$

4

(b) Prove :

(i) $\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = 1$

4

(ii) $\sigma_x \cdot \sigma_y \cdot \sigma_z = i$

where σ 's are Pauli spin matrices.

(c) Find expectation value of kinetic energy i.e. $\langle K.E. \rangle$ in ground state of hydrogen atom. 4

(d) Write first order energy correction for small perturbation. 4

UNIT - I

2. (a) Define a Hermitian operator and show that Hermitian operators have real eigen values. 8

(b) Show that Hamiltonian operator is a Hermitian operator. 4

(c) If $D|m\rangle = |b\rangle$, then show that $\langle b| = \langle m|D^\dagger$. 4

3. (a) Show that commutation relation between operators remain invariant under unitary transformation. 8

(b) Let $|\psi\rangle = 3i|\phi_1\rangle - 7i|\phi_2\rangle$ and

$$|\chi\rangle = -|\phi_1\rangle + 2i|\phi_2\rangle$$

where $|\phi_1\rangle$ and $|\phi_2\rangle$ are orthogonal.

Calculate :

(i) $|\psi + \chi\rangle$ and $\langle\psi + \chi|$ and 3

(ii) $\langle\psi|\chi\rangle$ and $\langle\chi|\psi\rangle$ 5

Are they equal ?

UNIT - II

4. (a) Establish angular momentum matrices

J_x, J_y, J_z, J_+, J_- and J^2 for $j = 3/2$. 12

(b) Evaluate : 4

(i) $[L_x, L_z]$ and

(ii) $[\sigma_z, \sigma_+]$.

5. Define raising and lowering operators J_+ and

J_- and calculate their eigen values. 16

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UNIT - III

6. Solve the problem of a three dimensional isotropic harmonic oscillator using Cartesian coordinates. What is the significance of zero point energy ? 16
7. Find out eigen wave functions of a hydrogen atom. 16

UNIT - IV

8. The Hamiltonian of a given physical system is of the form $H = H_0 + H'$, where H' is small perturbation to H_0 . Using time independent perturbation theory, calculate the corrections for the eigen functions and eigen values in the second order approximations. 16
9. What is Stark effect ? Explain Stark effect in normal hydrogen atom using stationary state perturbation theory. 16