Roll No. .....

DD-451

M. Sc. (Second Semester)
EXAMINATION, May-June, 2020

PHYSICS

(Quantum Mechanics—I)

Time : Three Hours

Maximum Marks : 80

Note : Attempt *five* questions in all, selecting *one* question from each Unit. All questions carry equal marks.

Unit—I

1. Discuss uncertainty relations and states with minimum uncertainty product. 16

Or

2. Derive time independent and time dependent Schrödinger equation for a free particle in one dimension. 16

Unit—II

3. (a) Discuss representation of states and dynamical variables in quantum mechanics. 10

   (b) Show that the necessary and sufficient condition for two operators to have simultaneous eigen functions is that they commute. 6

Or

4. (a) Discuss completeness and normalization of eigen functions. 8

(b) For three operators A, B and C, prove the commutation relation : 4

$$[AB, C] = A[B, C] + [A, C]B.$$

(c) If A and B are two operators, then show that : 4

$$\left[A, B^{-1}\right] = -B^{-1}[A, B]B^{-1}$$

Unit—III

5. Starting from commutation relationship of angular momentum operators, prove :

(a) J^2 commutes with J_+ and J_- 8

(b) $\left[J_+, J_-\right] = 2J_z\,\hbar$ 4

(c) $J^2 = \frac{1}{2}\left(J_+ J_- + J_- J_+\right) + J_z^2$ 4

Or

6. If σ_x, σ_y and σ_z are Pauli's matrices, evaluate σ_x, σ_y and σ_z. 16

Unit—IV

7. Write the Schrödinger equation with spherically symmetric potential in the spherical co-ordinates. By separation of variables method. Write three independent equation for radial and angular $(\theta \,\&\, d)$ equations. 16

Or

8. Compute the expectation value of $\frac{1}{r}$ i.e. $\left\langle \frac{1}{r} \right\rangle$ in the ground state of Hydrogen atom. Also compute the most probable value of r in this state, given that the wave function :

$$\psi_{100} = \sqrt{\frac{1}{\pi a_0^3}}\, e^{-\frac{r}{a_0}},$$

where a_0 is the Bohr radius. 16

Unit—V

9. Find the energy spectrum of a system whose Hamiltonian is :

$$H = \frac{-\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2 + ax^3 + bx^4,$$

where 'a' and 'b' are small constants using perturbation theory upto first order. 16

Or

10. Evaluate first order energy and wave function using time independent perturbation theory for non-degenerate system. 16