PG Odd Semester (CBCS) Exam., December—2018

PHYSICS

(1st Semester)

Course No. : PHYCC–103

(Quantum Mechanics—I)

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer **five** questions, taking **one** from each Unit

UNIT—I

1. *(a)* Discuss the photoelectric effect highlighting the inadequacies of classical physics to explain the phenomenon. 6

(b) Consider the states | $3i|_1$ $7i|_2$ and | | $_1$ $2i|_2$, where | $_1$ and | $_2$ are orthonormal.

(i) Calculate | and |. 2

(ii) Calculate the scalar product | and | . Are they equal? 3

(iii) Show that the states | and | satisfy the Schwartz and triangle inequalities. 3

2. *(a)* State the postulates of quantum mechanics. 6

(b) Let us consider a wave function

$$(x) \quad e^{\quad x^2}$$

where constant. Having the property $(x \quad 0) \quad 0$ and $(x \quad) \quad 0$, find the expectation values x , x^2 and $\frac{1}{x}$. 8

UNIT—II

3. Solve the Schrödinger equation for a particle of mass m in an infinite one-dimensional potential well of width a

$$V(x) \quad 0 \quad \text{for} \quad \frac{a}{2} \quad x \quad \frac{a}{2}$$
$$\text{otherwise}$$

and obtain the energy eigenvalues and the corresponding eigenfunctions. Does it have a solution if the total energy of the particle $E \quad 0$? 12+2=14

4. Consider a square potential barrier given by

$$V(x) \quad \begin{array}{ll} 0 & \text{for } x \quad 0 \\ V_0 & \text{for } 0 \quad x \quad l \\ 0 & \text{for } x \quad l \end{array}$$

Calculate the stationary states describing incident particles with energy $E \quad V_0$. Also compute the transmission co-efficient. 8+6=14

UNIT—III

5. *(a)* State and prove the generalized uncertainty principle. 1+5=6

(b) Recover Heisenberg uncertainty principle from it. 2

(c) Obtain the energy-time uncertainty principle $E \quad t \quad \frac{\hbar}{2}$ from the generalized uncertainty principle and interpret the quantities E and t in it. 6

6. *(a)* What are 'pictures' in quantum mechanics? 2

(b) Define the time evolution operator and state its properties. 5

(c) Using the time evolution operator, show how you can obtain the Heisenberg picture from the Schrödinger picture. 7

UNIT—IV

7. *(a)* Discuss the Schrödinger representation as an example of a continuous basis. 8

(b) Show that one representation may be obtained from another by means of a unitary transformation. 6

8. Solve the harmonic oscillator problem using operator method. Also obtain the harmonic oscillator wave functions. 9+5=14

UNIT—V

9. *(a)* Discuss angular momentum using operator method and obtain the eigenvalues of the total angular momentum. 9

(b) Obtain the matrix representation of the angular momentum operators. 5

10. *(a)* Discuss how two angular moments $\vec{J}_1$ and $\vec{J}_2$ are added. 6

(b) What are Clebsch-Gordan co-efficients? 2

(c) Obtain the Clebsch-Gordan co-efficients in the sum of angular momenta $j_1 \quad \frac{1}{2}$ and $j_2 \quad \frac{1}{2}$. 6

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