

Tribhuvan University

2081

Bachelor Level (4 Yrs.)/Science & Tech. / IV year

Quantum Mechanics

Full Marks: 100

PHY -401 (New Course)

Time: 3 hrs.

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

Attempt ALL the questions.

- ✓ 1. Define phase velocity and group velocity. Obtain an expression relating these two velocities and show that the group velocity is equivalent to particle velocity. [10]

OR

Find the rotational energy eigen function of the rigid rotator

- ✓ 2. Obtain the expressions of energy eigen value and eigen function for a particle in one dimensional infinitely deep potential well. [10]

OR

Describe the physical implications of Schrodinger equation.

- ✓ 3. State and prove Ehrenfest Theorem. [8]

4. Define a Hermitian operator. Write its significance. Show that the momentum and energy operators are Hermitian operators. [8]

- ✓ 5. What is zero point energy of Harmonic oscillator? Discuss the creation and annihilation operator of Linear Harmonic oscillator. [8]

6. Explain the importance of commutation relation and establish the relation between the two rectangular components of angular momentum operators. [8]

7. Answer all questions. [2×3=6]

- (a) Show that parity operator is linear..

OR

Is the transition $\psi_{200} \rightarrow \psi_{100}$ forbidden? Justify your answer.

- (b) We cannot observe the wave like properties of a fast moving cricket ball, why?

OR

Prove that $[\hat{L}_x, \hat{L}_y] = i\hbar \hat{L}_z$ Prove

8. Answer all questions.

[4×3=12]

- What is the physical significance of tunnelling effect?
- Explain the meaning of the radial wave function?
- State the postulates of the quantum mechanics.
- A proton and deuteron have same kinetic energy. Which has the longer wavelength?

9. Find the energy expectation value of a particle moving between l_1 and l_2 and described by the wave function $\psi(x, t) = e^{3ix-b}$. [5]

10. If $H = \frac{1}{2}m\dot{q}^2 + V(q)$ then show that $i\hbar\dot{q} = qH - Hq$ is satisfied if $qp - pq = i\hbar$ where $\dot{q} = \frac{dq}{dt}$. [5]

✓ 11. Calculate the probability of finding a simple harmonic oscillator within the classical limits if the oscillator is in the normal state. [5]

12. Radial part of wave function for hydrogen atom in ground state is $R = \frac{2}{a_0^{3/2}} e^{-r/a_0}$. Find the ground state of energy of hydrogen atom. [5]

✓ 13. The rotational constant of $C^{11}N^{14}$ is 1.91cm^{-1} . Calculate the bond length of $C^{11}N^{14}$. [5]

✓ 14. Estimate the de-Broglie's wave length of electron of kinetic energy 1 kilo electron volt. [5]