MANIPAL ACADEMY of HIGHER EDUCATION
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Reg. No. | | | | | | | | | |

DEPARTMENT OF SCIENCES, M. Sc. PHYSICS
I SEMESTER END SEMESTER EXAMINATIONS
DECEMBER 2018
Subject: Quantum Mechanics I (PHY-4105)
(REVISED CREDIT SYSTEM)

Time: 3 Hours   Date: December 2018   MAX. MARKS: 50

Note: (i) Answer all the questions.
(ii) Answer the questions to the point.

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1. (i) Describe a phenomena which shows particle nature of light. [5]
(ii) Show that the average kinetic energy of a particle of mass m with a wave function $\psi(x)$ can be written in the form

$$T = \frac{\hbar^2}{2m}\int_{-\infty}^{\infty}\left|\frac{d\psi}{dx}\right|^2 dx \qquad [5]$$

2. (i) Write the time dependent Schroedinger equation. Using separation of variable technique split it into purely time dependent and time independent components. [3]
(ii) What are stationary states? [2]
(iii) Show that the probability density of the linear harmonic oscillator in an arbitrary superposition state is periodic with the period equal to the period of the oscillator. [5]

3. (i) Calculate the energy eigenvalues and eigenfunctions of a particle confined in a two dimensional square shaped infinite deep potential well. Show that the eigenstates are degenerate. [5]
(ii) Calculate the energy difference between the stationary states $l = 1$ and $l = 2$ of the rigid molecule H_2. Use the Bohr frequency rule to estimate the frequency of radiation involved during transition between these two states. Suggest a method for determining the bond length of hydrogen molecule. [5]

4. Solve the Schroedinger equation for the hydrogen atom and discuss the radial wavefunction. [10]

5. (i) Write a short note on exchange operators. Calculate their eigenvalues. [5]

(ii) What is the ground state energy and wavefunction for two identical particles in an infinite deep potential of width a, if the two particles are (a) bosons, and (b) fermions? [5]

Useful formulae:

$$\nabla^2 t = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial t}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial \theta}\left(sin\theta \frac{\partial t}{\partial \theta}\right) + \frac{1}{r^2 sin^2\theta}\frac{\partial^2 t}{\partial \phi^2}$$

$$\int_0^\infty exp(-a^2x^2)cos(bx)\, dx = \frac{\sqrt{\pi}}{2a} exp\left(-\frac{b^2}{4a^2}\right)$$

$$\int_0^\infty x^n exp(-ax)\, dx = \frac{n!}{a^{n+1}}, \quad \textbf{where} \quad n \geq 0, \quad a > 0$$