Reg. No.										

Manipal University, Manipal
First Semester M.Sc.(Physics)
End Semester Examination, December 2015
Subject: Quantum Mechanics I (PHY-605)
(Credit System)

Time: 3 hours **Marks: 50**

Answer any five full questions.

1. (i) Electron scattering experiment gives a value of 2×10^{-15} m for the radius of a nucleus. Using relativistic expressions estimate the order of energies of electrons used for the experiment. [5]
(ii) The average lifetime of an excited atomic state is 10^{-9} s. If the spectral line associated with the decay of this state is 6000 Angstrom, estimate the width of the line. [5]
2. (i) Show that commuting operators have common set of eigenfunctions. [4]
(ii) Write down any two properties of a quantum mechanical wavefunction. [2]
(iii) What is the statistical interpretation of a wavefunction? [2]
(iv) What are stationary states? [2]
3. (i) Calculate the transmission coefficient for a stream of particles incident to a one dimensional square potential barrier. [8]
(ii) Explain the meaning of quantum tunneling. [2]
4. (i) Calculate the expectation values of position and of the momentum of the particle trapped in a one-dimensional box. [5]
(ii) Simplify the Schroedinger equation for hydrogen atom and obtain the radial component of the Schroedinger equation. [5]
5. (i) What are atomic orbitals? Explain in detail the p-orbitals of a hydrogen atom and represent them graphically. [5]
(ii) A crystal has some negative ion vacancies, each containing one electron. Treat these electrons as moving freely inside a cubical volume whose dimensions are of the order of lattice constant equal to 10^{-10} m. Assuming the value of lattice constant, estimate the longest wavelength of electromagnetic radiation absorbed by these electrons. [5]

6. Consider two noninteracting electrons described by the Hamiltonian

$$H = \frac{p_1^2}{2m} + \frac{p_2^2}{2m} + V(x_1) + V(x_2)$$

where $V(x) = 0$ for $0 < x < a$; $V(x) = \infty$ for $x < 0$ and for $x > a$. If both the electrons are in the same spin state, what is the lowest energy and eigenfunction of the two electron system. [10]

Useful formulae:

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

Mass of an electron $m_e = 9.1 \times 10^{-31}$kg.