B.Sc. (Semester – V) Examination, October/November 2016
PHYSICS (Paper – II)
Wave Mechanics

Duration : 2 Hours Total Marks : 80

Instructions : 1) ***All** questions are **compulsory**.*
2) *Figures to the **right** indicate **marks**.*
3) ***Symbols** have their usual meaning unless otherwise stated.*
4) *Draw **neat** diagrams **wherever** necessary.*
5) ***Use** of calculator is **permitted**.*

Constants : $h = 6.63 \times 10^{-34}$ J.sec. $e = 1.6 \times 10^{-19}$ C.
$m_e = 9.1 \times 10^{-31}$ Kg. $m_p = 1.66 \times 10^{-27}$ Kg.

1. Answer **any four** of the following : (4×4=16)

a) State Bohr's postulate regarding quantization of angular momentum of the electron in a hydrogen atom. Obtain Bohr's postulate regarding quantization of angular momentum on the basis of stationary de Broglie waves.

b) What is meant by group velocity and particle velocity ? Show that for a simplest type of a wave travelling along the x-axis, for a point of constant phase, a point of constant phase travels with a velocity called the phase velocity.

c) Obtain Heisenberg's Uncertainty Principle relating uncertainties in energy and time. Show that it leads to a natural width for the spectral lines.

d) Construct Schrodinger's time independent equation for a particle moving in a potential V.

e) Explain the terms Eigen values and Eigen functions. What is meant by symmetric and antisymmetric wave functions ?

f) Explain the phenomenon of α - decay using the theory of tunnel effect.

2. Answer **any four** of the following : (4×4=16)

a) State de Broglie's hypothesis. Derive an expression for de Broglie's wavelength in terms of accelerating potential V.

b) What is meant by well behaved wave function and normalized wave function ? State the conditions that an acceptable wave function must satisfy.

c) For a particle represented by a wave group, prove the Heisenberg's Uncertainty relation $\Delta p.\Delta x \geq h/4\pi$, where Δx is the uncertainty in the location of the wave and Δp is the simultaneous uncertainty in its momentum.

d) Explain what is meant by expectation value of physical observables. Show that the expectation values $<px> - <xp> = h/2\pi i$.

e) For a particle in a symmetric potential, prove that the non-degenerate eigen functions must have a definite parity.

f) Write the Schrodinger's time dependent equation for the motion of the particle inside a rectangular three dimensional box. What is meant by degenerate and non-degenerate states of an energy level ?

3. A) a) Find the potential difference through which an electron should be accelerated so that the de Broglie wavelength associated with the electron is 1A∪. 3

b) Describe the construction of a wave group associated with a particle by superimposing two wave trains, slightly differing in angular frequency ω and propagation constant K, while their amplitudes remain the same. 3

OR

A) x) Give Max Born's interpretation of wave function. The eigen function of a particle is given to be $\psi(x) = A\,\mathrm{Sin}(\pi x/L)$ for $0 < x < L$ and 0 elsewhere. Normalize $\psi(x)$. 3

y) Find the de Broglie wavelength of 1000 eV electrons. 3

B) Describe G.P. Thomson experiment which demonstrate the wave like properties of a beam of electrons. 6

4. A) a) Compare the uncertainties in the velocities of an electron and a proton confined in 10 A∪ box. 2

b) Describe the experiment "diffraction by a slit" which supports the uncertainty principle. 4

OR

A) x) Using the energy and momentum operators, deduce Schrodinger's time dependent equation for a x particle. 2

y) Illustrate Heisenberg's Gamma Ray Microscope experiment. 4

B) Obtain Schrodinger's time dependent equation using a free particle wave function. 6

5. A) a) Verify the operator equation $(d/dx - \alpha x)(d/dx + \alpha x) = d^2/dx^2 - \alpha^2 x^2 + \alpha$. Given that α is a constant. 3

b) Determine the transmission coefficient of a particle moving in a one dimensional potential given by $V = 0$ for $x < 0$ and $V = V_0$ for $x > 0$ for the energy of the particle $E > V_0$. 3

OR

A) x) If φ_1 and φ_2 degenerate eigen functions of the linear operator O, show that $\varphi = c_1 \varphi_1 + c_2 \varphi_2$ is an eigen function of operator O with the same eigen value as that of φ_1 and φ_2. 3

y) Determine the transmission coefficient of a particle moving in a one dimensional potential given by $V = 0$ for $x < 0$ and $V = V_0$ for $x > 0$ for the energy of the particle $E < V_0$. 3

B) Write down the Schrodinger's wave equation for a linear harmonic oscillator. Show that its minimum energy is non-zero. Find eigen values of energy. 6

6. A) a) A pendulum has a length of L meters and a bob of mass 0.1 kg. Find its zero point energy. 3

b) What is a parity operator ? How does it distinguish between odd and even functions ? Obtain its eigen values. 3

OR

A) x) What is meant by zero point energy of a harmonic oscillator ? What is its significance ? 3

y) Find the expectation value of position of a particle if wave function $\psi(x) = ax$ between $x = 0$ and $x = 1$ and zero every where else. 3

B) Solve the Schrodinger's wave equation for a particle of mass m in a one dimension infinite potential well of width L. Write normalized eigen functions and the eigen values of the three lowest states. 6
