TMG – 11

B.Sc. (Semester – V) Examination, April 2019
PHYSICS (Paper – II)
Wave Mechanics

Duration : 2 Hours　　　　Total Marks : 80

Instructions : 1) ***All*** *questions are* ***compulsory****.*
2) *Figures to the* ***right*** *indicate* ***full*** *marks.*
3) ***Symbols*** *have their usual meaning unless otherwise stated.*
4) *Draw* ***neat*** *diagrams* ***wherever*** *necessary.*
5) *Use of calculator is* ***permitted****.*
6) *Given :* $h = 6.62 \times 10^{-34}$ J-s; $e = 1.6 \times 10^{-19}$ C; $m_e = 9.1 \times 10^{-31}$ Kg. $m_n = 1.67 \times 10^{-27}$ kg.

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

a) What is a wave group ? How it is produced ? What is the physical significance of phase velocity ?

b) State De Broglie's hypothesis. Show that the De Broglie's wavelength of a gas particle of mass m at a temperature T is = $h/(3mkT)^{1/2}$, where k is Boltzmann's constant.

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

d) What is a parity operator ? How does it distinguish between odd and even functions ?

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

f) Write the expression for energy of a particle in a cubical box of each side L and hence explain what is meant by degenerate and non-degenerate states of energy levels ?

P.T.O.

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

a) State the Bohr's postulate about stationary states in view of De Broglie's hypothesis. If two particles are accelerated through voltages of 100V and 400V, what is the ratio of their wavelengths ?

b) State the conditions that acceptable wave functions must satisfy.

c) For a particle represented by a wave group, prove that the Heisenberg's Uncertainty relation $\Delta\lambda . \Delta x \geq \frac{\lambda^2}{4\pi}$, where Δx is the uncertainty in the location of the wave and $\Delta\lambda$ is the simultaneous uncertainty in its wavelength.

d) Prove the following commutation relation :
$[[A, B], C] + [[B, C], A] + [[C, A], B] = 0.$

e) Explain the phenomena of tunnel diode problem using the theory of potential barrier.

f) Sketch the eigen function $\psi(x)$ and corresponding probability densities $\psi(x)^* \psi(x)$ for the states n = 1, 2 and 3 for a particle in a one dimensional box.

3. A) a) Describe the construction of 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

b) Find the potential difference through which an electron should be accelerated so that the De Broglie's wavelength associated with the electron is 1A°. 3

OR

x) Give Max Born's Interpretation of wave function. What is meant by normalization of wave function ? 3

y) In a Davison and Germer experiment using neutrons, a 0.083eV beam is scattered from a target to give a first order Bragg reflection at 22°. Calculate the Bragg plane spacing responsible for the electron. 3

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

4. A) a) Describe the experiment, "diffraction by a slit" which supports the uncertainty principle. 3

b) An atom in excited state decays by emission of radiation. If the excited state has on the average a life time of 10^{-8} sec, calculate the uncertainty ΔE in the energy E of the excited atom. 3

OR

x) Using energy and momentum operators, deduce Schrödinger's time dependent equation for a particle. **3**

y) Illustrate Heisenberg's Gamma Ray Microscope experiment. **3**

B) Obtain Schrödinger's time dependent equation using a free particle wave equation. **6**

5. A) a) Prove the operator equation. **3**

$$\left(\frac{d}{dy}+y\right)\left(\frac{d}{dy}-y\right)=\frac{d^2}{dy^2}-y^2+1$$

b) An eigen function of the operator $\frac{d^2}{dx^2}$ is $\psi(x)=\sin(4x)$, find the corresponding eigen value. **3**

OR

x) 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**

y) If ψ_1 and ψ_2 are degenerate eigen function of the linear operator A, show that $\psi = c_1\psi_1 + c_2\psi_2$ is an eigenfunction of operator A with the same eigenvalue as that of ψ_1 and ψ_2. **3**

B) Write down Schrödinger's wave equation for a linear harmonic oscillator. Show that its minimum energy is non-zero. Find eigenvalue of energy. **6**

6. A) a) State any three basic postulates of quantum mechanics. **3**

b) A pendulum has a length of 1 meter and a bob of mass 0.1Kg. Find its zero point energy. **3**

OR

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

y) Consider a particle in a finite rectangular potential well given by $V(x) = 0$ for $|x| < a$ and $V(x)=V_0$ for $|x| > a$, how that there are two classes of solutions having a definite parity. **3**

B) Solve the Schrödinger's wave equation for a particle of mass m in a one dimensional infinite potential well of width L. Write normalized eigenfunctions and the eigenvalues of the three lowest states. **6**
