2024
B.A./B.Sc.
Fourth Semester
GENERIC ELECTIVE – 4
PHYSICS
Course Code: PHG 4.11
(Elements of Modern Physics)

Total Mark: 70 *Pass Mark: 28*
Time: 3 hours

Answer five *questions, taking* one *from each unit.*

UNIT–I

1. (a) Explain in short Planck's quantum theory. 3
   (b) What is Compton effect? Derive an expression for the change in wavelength of scattered photon in Compton effect. 1+6=7
   (c) X-rays of wavelength 10Å are scattered from a target. 4
      (i) Find the wavelength of the X-rays scattered through 45°.
      (ii) Find the maximum wavelength present in the scattered X-rays.

2. (a) Describe Davisson and Germer's experiment for the study of diffraction of electrons. 4
   (b) State the postulates of Bohr's theory of the hydrogen atom. Derive the expressions for radius of Bohr orbit and energy of the electron in the n^{th} orbit. Draw the energy level diagram of the hydrogen atom and hence explain the various spectral series of this atom. 2+4+4=10

UNIT–II

3. (a) Derive the time-independent Schrodinger's wave equation for a particle in three dimensions. 12
   (b) What is the physical significance of a wave function? 2

4. (a) Explain normalization of a wave function. 2
   (b) Using time dependent form of the wave function deduce operators for momentum and energy. 3+3=6

(c) Prove the relation $\frac{\partial P}{\partial t} + \nabla . J = 0$ where J is probability current density and P the probability density. 3

(d) A particle is in motion along a line between $x = 0$ and $x = a$ with zero potential energy and at points for which $x < 0$ and $x > a$ the potential energy is infinite. The wave function for a particle in the nth state is given by:

$$\psi_n = A \sin \frac{n\pi x}{a}$$

Find the expression for the normalized wave function. 3

UNIT–III

5. (a) A particle of mass m is confined to a one-dimensional closed box of infinite rigid walls at $x = 0$ and $x = L$. Assuming that it does not lose energy in collisions with the walls. Obtain an expression for the normalized wave function and calculate the values of energy of the particle in a one-dimensional box. 10

(b) Find the lowest energy of an electron confined to move in a one-dimensional potential box of length 1 Å. 4

6. (a) What is potential step? Find the reflection and transmission co-efficient for potential step of the form $E < V_o$. Show that there is a finite probability of locating the particle in the region which is forbidden classically. 12

(b) What is quantum mechanical tunnelling? Give one example. 2

UNIT–IV

7. (a) State Heisenberg uncertainty principle for measurement of position and momentum. Using gamma ray microscope thought experiment, obtain an expression for uncertainty relation. Discuss its physical importance. 2+4+2=8

(b) Explain the concept of energy and time uncertainty. 3

(c) Calculate the uncertainty in the position of an electron moving with a velocity 300 m/s, with uncertainty 0.001%. 3

8. (a) Obtain the Heisenberg's uncertainty principle from de Broglie wave concept. 5
   (b) Explain non-existence of free electrons in the nucleus. 3
   (c) Calculate the uncertainty in the momentum and velocity of an electron confined in a box of length 1 Å. 3
   (d) Explain any two properties of a nucleus. 3

UNIT–V

9. (a) Discuss the nature of nuclear force. Plot the *N-Z* graph for stable nuclei and explain nuclear stability. 3+3=6
   (b) Write the semi empirical mass formula for a nucleus of mass number *A*, containing *Z* protons and *N* neutrons explaining each term used in the expression. 5
   (c) Calculate the half-life period of radium if 1 gram of radium is reduced by 2.1 mg in 5 years by α decay. 3

10. (a) Explain the existence of continuous spectrum of β particles. Show how neutrino hypothesis accounts for continuous β -ray spectrum. 3+3=6
   (b) Calculate the kinetic energy of the alpha particle emitted by the decay of $^{222}_{86}Rn$. Given mass of $^{222}_{86}Rn$ = 222.017531 u. Mass of polonium nucleus =218.008930 u and mass of alpha particle = 4.00260 u. 3
   (c) Write short notes on the following: 2+3=5
      (i) Electron capture
      (ii) Internal conversion