2023

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) State the Planck's hypothesis to explain the spectral distribution of the intensity of radiation from a black body? Derive Planck's radiation law. 3+5=8
   (b) Derive Einstein's photoelectric equation. 3
   (c) Calculate the work function in electron volts of a metal, given that photoelectric threshold wavelength is 6800 Å. 3

2. (a) Derive the de Broglie relation for matter waves. 3
   (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 emission of the Lyman and Balmer series of lines. 2+3+4=9
   (c) Find the longest wavelength present in the Balmer series of hydrogen, corresponding to the $H\alpha$ line. 2

UNIT–II

3. (a) Deduce the time-independent Schrodinger's wave equation. Give the significance of the wave function. 10+2=12
   (b) Give the conditions for a well behaved wave function. 2

4. (a) State the postulates of quantum mechanics. 3
   (b) Using time dependent form of the wave function, deduce the operators for momentum and energy. 3+3=6
   (c) Explain the normalization of a wave function. 2
   (d) Normalise the one dimensional wave function given by
   $\Psi(x) = A\sin(\pi x a), \quad 0 < x < a$
   $\Psi(x) = 0, \qquad$ outside 3

UNIT–III

5. (a) A particle of mass m is confined to a one dimensional closed box with infinitely rigid walls at $x = 0$ and $x = L$. Calculate the values of energy of the particle in a one-dimensional box. Obtain the corresponding wave functions. 10
   (b) Find the lowest energy of a neutron confined to a nucleus of size 10^{-14} m. Given, mass of the neutron = 1.67×10^{-27} kg. 4

6. (a) A particle of mass m travelling along x-axis has a potential barrier defined as $V(x) = \begin{cases} 0, & x < 0 \\ V_0, & x > 0 \end{cases}$
   Calculate the expression for reflection and transmission coefficient of the particle. 12
   (b) What is quantum mechanical tunnelling? 2

UNIT–IV

7. (a) Derive Heisenberg's uncertainty relation from a hypothetical gamma ray microscope. Discuss its physical importance. 6+2=8
   (b) State time energy uncertainty relation and obtain it from position momentum uncertainty principle. 3
   (c) The position and momentum of 0.5 keV electron are simultaneously determined. If its position is located within 0.2 nm, what is the percentage uncertainty in its momentum? 3

8. (a) Explain the non-existence of free electrons in the nucleus. 3

(b) By applying uncertainty principle, explain minimum energy of harmonic oscillator and existence of finite zero point energy. 2+2=4

(c) Life time of a nucleus in the excited state is 10^{-12} s. Calculate the probable uncertainty in energy and frequency of a γ ray photon emitted by it. 4

(d) Explain any two properties of nucleus. 3

UNIT–V

9. (a) Define the terms decay constant, half life, and average life as applied to a radioactive substance. Find the relation between them. 3+4=7

(b) State and explain the laws of radioactive disintegration process. 4

(c) The half life of U_{92}^{238} is 4.51×10^{9} years. What percentage of U_{92}^{238} that existed 10^{10} years ago still survives? 3

10. (a) Explain the existence of continuous spectrum of β particles. Describe the neutrino theory of β decay. 3+3=6

(b) The polonium isotope Po_{84}^{210} is unstable and emits a 5.30 MeV alpha particle. The atomic mass of Po_{84}^{210} is 209.9829 u and that of He_{2}^{4} is 4.0026 u. Identify the daughter nuclide and find its atomic mass. 3

(c) Write short notes on the following: 2+3=5

(i) Nuclear isomerism

(ii) Internal conversion