2022

B.A./B.Sc.

Fourth Semester

CORE - 9

PHYSICS

Course Code: PHC 4.21

(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) Show that Compton shift in the wavelength is given by

$$\delta\lambda = \frac{h}{m_0 c}\left(1 - cos\,\phi\right)$$ 6

(b) In an experiment, tungsten cathode which has a threshold 2300 Å is irradiated by ultraviolet light of wavelength 1800Å. Calculate
(i) The maximum energy of the emitted photoelectrons and
(ii) Work function of tungsten
[h = 6.6×10^{-34} Js, 1ev = 1.6×10^{-19}J] 5

(c) Derive Planck's radiation law in terms of wavelength. 3

2. (a) Derive uncertainty principle from wave packet. Using uncertainty principle explain the nonexistence of electron in the nucleus and also calculate the zero point energy of a Harmonic Oscillator. 5+3+3=11

(b) Explain the determination of position with gamma-ray microscope. 3

UNIT–II

3. (a) Explain degeneracy. Derive time dependent form of Schrodinger's equation in 3-D. 2+5=7

(b) What are the operators? Show that the momentum operator and the total energy operator in 3-D are given by $\hat{p} = -i\hbar\nabla$ and

$\hat{H} = \frac{-\hbar^2}{2m}\nabla^2 + V(r)$ respectively. 1+3+3=7

4. (a) Derive the relation between probability density and probability current density. 5

(b) Normalize the 1-D wave function given by

$$\psi = \begin{cases} A\sin\left(\frac{\pi x}{a}\right), 0 < x < a \\ 0, \text{outside} \end{cases}$$

and find the probability current density. 5

(c) Normalize the wave function $\psi = Ae^{ikx}$ over the region $-a \le x \le a$ and find the probability of existence of the particle between $x = -a$ and $x = \frac{-a}{4}$. 4

UNIT–III

5. (a) Prove that the transmission coefficient is not zero for the potential

barrier $V(x) = \begin{cases} 0, & x < 0 \\ V, & 0 < x < L \\ 0, & x > L \end{cases}$

and explain the tunneling effect. 7+2=9

(b) State the values of momentum and energy of a particle in 1-D box with impenetrable walls. Find their values for an electron in a box of length 1 Å for n = 1 and n = 2 (mass of electron = 9.1×10^{-31} kg) 5

6. (a) Write the semi empirical mass formula and explain each terms in detail. 5

(b) Explain Gamow's theory of alpha-decay. 6

(c) Given that
mass of deuteron nucleus = 2.013553 μ
mass of proton = 1.007276 μ
mass of neutron = 1.008665 μ.
Calculate the mass defect and the binding energy of deuteron. 3

UNIT–IV

7. (a) Explain half-period of a radioactive element and derive an expression for it. If 1 gram of radium is reduced by 2.0 mg in 5 years by alpha-decay, calculate the half period of radium. 3+3=6

(b) Define mean life of a radioactive element. Prove that mean life $\bar{T} = \frac{1}{\lambda}$. If 1 gm of a radioactive substance disintegrates at the rate of 3.7×10^{10} disintegration per second, where the atomic weight of the substance is 226, calculate its mean life. 1+4+3=8

8. (a) Explain the energy spectrum of β-particles using magnetic spectrograph and discuss the neutrino theory of β-decay for continuous β-ray spectrum. 5+3=8

(b) Discuss the origin and the theory of γ-emission. 6

UNIT–V

9. (a) Define nuclear fission and explain it on the basis of Bohr and Wheeler theory. 1+3=4

(b) Explain the mass distribution of fission fragments for different fission chain of $^{235}_{92}U$. 5

(c) Explain carbon-nitrogen cycle as source of stellar energy. 5

10. (a) What is population inversion? Explain in detail the working of a He–Ne LASER. 2+5=7

(b) Derive the relation between Einstein coefficient and explain their results. 4+3=7
