3 (Sem–4/CBCS) PHY HC 2

2022

PHYSICS

(Honours)

Paper : PHY–HC–4026

(Elements of Modern Physics)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer ***any seven*** questions of the following : 1×7=7

   (a) What is the rest mass of photon ?

   (b) Define work function in the phenomenon of photoelectric effect.

(c) What is confirmed by Davisson and Germer experiment?

(d) What is wave particle duality?

(e) What is quantum dot?

(f) The volume of 80^{16} nucleus is V. What is the volume of $_{29}Cu^{64}$ nucleus?

(g) Write the relation between half life and mean life.

(h) At what energy range, gamma photon shows the Compton effect?

(i) What is the main source of solar energy?

(j) What is pumping in LASER technology?

2. Answer ***any four*** of the following : 2×4=8

(a) What is virtual particle?

(b) Explain eigenfunction and eigenvalues of an operator.

(c) Show that nuclear density is independent of the mass number.

(d) Write *two* properties of nuclear force.

(e) If the half life of a radioactive substance is 15 seconds, calculate its decay constant.

(f) Calculate the energy released from the fission of $10gm\ U^{235}$. [Energy per fission is $200MeV$]

(g) Write *two* properties of LASER.

(h) Write *two* necessary conditions for nuclear fusion reaction.

3. Answer ***any three*** questions of the following : 5×3=15

(a) Derive the one-dimensional time dependent Schrödinger equation for a moving free particle.

(b) Find the expression of momentum operator.

(c) Discuss the magic number in the context of nuclear shell model.

(d) State the law of radioactivity and derive it mathematically. 2+3=5

(e) Explain the fine structure of α decay.

(f) Write a short note on pair production process.

(g) What is nuclear fission reactor? Describe the main parts of a nuclear reactor. 1+4=5

(h) Explain the following :

(i) Spontaneous emission

(ii) Stimulated emission

(iii) Metastable states

4. Answer ***any three*** question of the following : 10×3=30

(a) What is Compton scattering? Explain the experimental arrangement of Compton scattering. Derive the expression of Compton shift. 1+3+6=10

(b) State Heisenberg uncertainty principle. Derive this principle from wave packets. 2+8=10

(c) A particle of mass m is confined in a one-dimensional infinitely rigid box of length L. The potential function is given by

$$\begin{aligned} V(x) &= \alpha, \quad x \le 0 \\ &= 0, \quad 0 < x < L \\ &= \alpha, \quad x \ge L \end{aligned}$$

(i) Find the wave function of the particle inside the box.

(ii) Find the expression of energy eigenvalues. 6+4=10

(d) Derive the expression of transmission coefficient and reflection coefficient, when a particle of mass m, kinetic energy E is incident on a one-dimensional potential barrier, if the kinetic energy is greater than the potential of the barrier. 5+5=10

(e) Derive the expression of semi-empirical mass formula and explain each term involved in this expression. 6+4=10

(f) Explain the continuous beta decay spectrum. What are the difficulties in interpreting this continuous spectrum? How did Pauli resolve these difficulties? 3+4+3=10

(g) Explain the construction and different operating regions of a gas-filled detector. 3+7=10

(h) Describe the construction and working of Ruby LASER. Mention *two* applications of Ruby LASER. (4+4)+2=10
