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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.

Contd.

- (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 ${}_{29}\text{Cu}^{64}$ 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 10 gm U^{235} . [Energy per fission is 200 MeV]
- (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

$$\begin{aligned} V(x) &= \alpha, & x \leq 0 \\ &= 0, & 0 < x < L \\ &= \alpha, & x \geq L \end{aligned}$$

(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
