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3 (Sem-4/CBCS) PHY HC 2

2023

**PHYSICS**

(Honours Core)

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 the following questions :  $1 \times 7 = 7$
- (a) What is the quantum of light ?
  - (b) What is the momentum of an electron if its de Broglie wavelength is  $1 \text{ \AA}$  ?
  - (c) What is wave particle duality ?
  - (d) Write one limitation of wave function  $\psi$ .

Contd.

- (e) Write the relation between half life and mean life of a radioactive sample.
- (f) What is the radius of a nucleus of mass number 125 ?
- (g) What is the function of a moderator in a nuclear reactor ?

2. Answer the following questions :  $2 \times 4 = 8$

- (a) Explain why Compton effect cannot be observed with visible light.
- (b) The threshold wavelength of a metal is  $6000 \text{ \AA}$ . Find the work function of the metal.
- (c) What is the physical significance of a wave function ?
- (d) Explain why pair production cannot take place in vacuum.

3. Answer **any three** questions from the following :  $5 \times 3 = 15$

- (a) Find the expression of minimum energy of a confined particle using uncertainty principle.
- (b) Define commutator. Show that position and momentum operators do not commute.  $1 + 4 = 5$

- (c) What is binding energy of a nucleus ? Draw a graph of binding energy per nucleon *vs* mass number of different nuclei. Write *one* conclusion that can be drawn from the graph.  $2+2+1=5$
- (d) Write how magic numbers can be explained from nuclear shell model.
- (e) What is  $\alpha$  decay ? Explain fine structure of  $\alpha$  energy spectrum.  
 $1+4=5$

4. Answer **any three** questions taking **at least one** from each group (maximum **two** questions from **one** group):  $10 \times 3 = 30$

### GROUP-A

- (a) What are phase velocity and group velocity ? Deduce the expressions of phase velocity and group velocity. Derive the relation between these velocities.  $2+3+3+2=10$
- (b) Derive Schrödinger equation for a non-relativistic free particle.

- (c) A particle of mass  $m$  and KE  $E$  is moving along positive  $X$  axis towards a finite potential step whose potential function is

$$V(x) = \begin{cases} 0 & \text{for } x < 0 \\ V_0 & \text{for } x > 0 \end{cases}$$

Show that for  $E > V_0$  the incident particle has certain probability of being reflected and certain probability of being transmitted.

### GROUP-B

- (d) What are the different modes of beta decay ? Explain the nature of  $\beta$  particle spectrum. What are the difficulties in interpreting the spectrum ? 3+3+4=10
- (e) Explain, in detail, the construction and different operating regions of a gas-filled detector. 3+7=10
- (f) Explain the terms 'optical pumping' and 'population inversion'. Explain the three level pumping LASERS and mention two drawbacks of this type of LASER. 2+2+4+2=10