Total number of printed pages–4

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 :   1×7=7

   (a) What is the quantum of light ?

   (b) What is the momentum of an electron

       if its de Broglie wavelength is 1Å ?

   (c) What is wave particle duality ?

   (d) Write *one* limitation of wave function
       ψ .

(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 :   2×4=8

(a) Explain why Compton effect cannot be observed with visible light.

(b) The threshold wavelength of a metal is $6000 \overset{\circ}{A}$. 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 :   5×3=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 α decay ? Explain fine structure of α energy spectrum.   1+4=5

4. Answer *any three* questions taking *at least one* from each group (maximum *two* questions from *one* group) :   10×3=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 β particle spectrum. What are the difficulties in interpreting the spectrum ? $\qquad$ 3+3+4=10

(e) Explain, in detail, the construction and different operating regions of a gas-filled detector. $\qquad$ 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. $\qquad$ 2+2+4+2=10

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