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**3 (Sem-4/CBCS) PHY HC 2**

**2021**

**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.***

**GROUP-A**

1. Choose the correct option : 5

(i) The momentum of a photon of energy  $E$  is :

(a)  $E/c$

(b)  $E^2/c$

*Contd.*

(c)  $c/E^2$

(d)  $Ec$

(ii) The Schrödinger equation contains :

(a) First-order time derivative

(b) First-order space derivative

(c) Second-order time derivative

(d) Third-order time derivative

(iii) What is the transmission coefficient for a particle incident on a step potential with energy greater than step height ?

(a) 1

(b)  $<1$

(c) 0

(d) infinite

(iv) Which combinations of radioactive emissions will not change the mass number of radioactive nuclei ?

(a) Alpha and beta decays

(b) Alpha and gamma decays

(c) Beta and gamma decays

(d) Alpha, beta and gamma decays

(v) What process creates energy in the Sun ?

(a) Fission

(b) Gamma emission

(c) Fusion

(d) Electro-magnetic interaction

2. Answer the following question :  $2 \times 5 = 10$

(a) Find the de Broglie wavelength of an electron having kinetic energy of 1 *Mev*.

(b) What is the physical significance of a wave function ?

(c) What is tunneling in Quantum mechanics ? Give *one* example.

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

(e) If the loss in mass during a fission is 0.01 *gm*, how much energy in *Mev* will be produced ?

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

- (a) Derive Heisenberg's Uncertainty principle from wave packets.
- (b) Explain normalization of a wave function. How is normalization expressed mathematically ?
- (c) Define Commutator. Show that position and momentum operator do not commute.
- (d) Explain the process of gamma emission.
- (e) Explain the working of nuclear reactor.

### **GROUP-B**

4. Answer **any three** questions from the following :  $10 \times 3 = 30$

- (a) What are phase velocity and group velocity ? Deduce the expression of phase velocity and group velocity and hence derive the relation between these two velocities.  $2+3+3+2$

- (b) Solve the Schrödinger equation for a free particle in a one-dimensional infinitely rigid box and obtain the eigenfunctions and corresponding eigenvalues. 6+4
- (c) Express the binding energy of a nucleus according to the semi-empirical mass formula and explain each term involved in the expression. 10
- (d) Explain the nature of beta particle spectrum. How Pauli's neutrino hypothesis able to explain the conservation laws of energy and linear momentum ? 4+6
- (e) Explain the terms — optical pumping and population inversion. Explain the three- level pumping LASERS and mention *two* drawbacks of this type of LASERS. 2+2+4+2