

**4 SEM TDC PHYH (CBCS) C 9**

**2023**

( May/June )

**PHYSICS**

( Core )

Paper : C-9

**( Elements of Modern Physics )**

*Full Marks : 53*

*Pass Marks : 21*

*Time : 3 hours*

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

1. Choose the correct answer from the following : 1×5=5

(a) Which of the following expressions represents thermal de Broglie wavelength of a particle?

(i)  $\lambda = \frac{h}{\sqrt{3mkT}}$

(ii)  $\lambda = \frac{h}{\sqrt{3kT}}$

(iii)  $\lambda = \frac{2h}{\sqrt{3mkT}}$

(iv)  $\lambda = \frac{h}{\sqrt{kT}}$

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( Turn Over )

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- (b) The nuclear density
- (i) is independent of size of nucleus
  - (ii) increases with increasing size of nucleus
  - (iii) decreases with increasing size of nucleus
  - (iv) None of the above
- (c) The existence of zero-point energy is in conformity with
- (i) Compton effect
  - (ii) uncertainty principle
  - (iii) de Broglie hypothesis
  - (iv) None of the above
- (d) A metastable state has lifetime of the order of
- (i)  $10^{-6}$  s
  - (ii)  $10^{-5}$  s
  - (iii)  $10^{-4}$  s
  - (iv)  $10^{-3}$  s
- (e) Which of the following cannot be emitted by a radioactive substance during their decay?
- (i) Neutrino
  - (ii) Protons
  - (iii) Helium nuclei
  - (iv) Electrons

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( Continued )

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2. Answer the following questions : 2×5=10

- (a) What is photoelectric effect? Define work function of a material.
- (b) What are three-level and four-level lasers? Give examples of each type.
- (c) Write down the semi-empirical mass formula for a nucleus. Define binding energy.
- (d) Show that the phase velocity is half of the group velocity for a non-relativistic free particle.
- (e) Describe how an electron-positron pair is created by gamma photons in the vicinity of a nucleus.

3. (a) Explain the validity of Heisenberg's uncertainty principle using the gamma ray microscope thought experiment. 3

(b) Normalize the following wave function in one dimension : 3

$$\begin{aligned}\psi(x) &= Ae^{-\alpha x} \text{ for } x > 0 \\ &= Ae^{\alpha x} \text{ for } x < 0\end{aligned}$$

where  $\alpha$  is a positive constant.

(c) Briefly explain the two cyclic processes involved in the thermonuclear fusion in driving stellar energy. 3

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4. (a) What is a wave function? How can the stationary states of a particle be explained using the concept of wave function? 1+3=4

(b) Obtain the energy eigenvalues and eigenfunctions for a particle in a one-dimensional rigid box. 4

Or

Derive the time-dependent Schrödinger equation for a non-relativistic particle. 4

5. (a) Derive an expression for Planck's law of radiation. 6

(b) Explain the quantum mechanical tunnelling for a particle across a step potential and obtain the expression for transmission coefficient. 6

(c) Obtain an expression for the law of radioactive decay. Show that the half-life of a radioactive substance is inversely proportional to its decay constant. 3+3=6

6. Write a short note on (any one) : 3

(a) Davisson and Germer experiment

(b) Liquid-drop model

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