

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

(2)

- (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

(3)

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
- $$\psi(x) = Ae^{-\alpha x} \text{ for } x > 0$$
- $$= Ae^{\alpha x} \text{ for } x < 0$$
- where α is a positive constant.
- (c) Briefly explain the two cyclic processes involved in the thermonuclear fusion in driving stellar energy. 3

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
