Student's Copy

2023

(CBCS)

(5th Semester)

PHYSICS

SEVENTH PAPER

(Classical Mechanics and Nuclear Physics)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(SECTION : A—OBJECTIVE)

(*Marks* : 10)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×10=10

1. If q_j is a cyclic coordinate, then the corresponding conjugate momentum p_j

(a) is infinite ( )

(b) is constant ( )

(c) varies according to the potential ( )

(d) All of the above ( )

2. Kepler's second law of planetary motion is a direct consequence of

(a) conservation of linear momentum ( )

(b) conservation of angular momentum ( )

(c) property of central force ( )

(d) transformation of coordinate system ( )

3. Two different nuclei having the same mass number, but different atomic numbers are called

(a) isotones ( )

(b) isobars ( )

(c) isomers ( )

(d) mirror nuclei ( )

4. Electric quadrupole moment of nuclei accounts for

(a) nuclear charge distribution ( )

(b) nuclear spin symmetry ( )

(c) nuclear power ( )

(d) nuclear binding energy ( )

5. J-J coupling plays the dominant role in

(a) light nucleus ( )

(b) medium nucleus ( )

(c) heavy nucleus ( )

(d) all nucleus ( )

6. In a gamma decay of the nucleus

(a) A increases and Z decreases ( )

(b) A decreases and Z increases ( )

(c) A and Z increase or decrease together ( )

(d) A and Z remain unchanged ( )

7. Linear Accelerator (LINAC) works with

(a) alternating electric field ( )

(b) static electric field ( )

(c) alternating magnetic field ( )

(d) static magnetic field ( )

8. Which of the following is cyclic accelerator?

(a) Betatron ( )

(b) Synchrotron ( )

(c) Synchrocyclotron ( )

(d) All of the above ( )

9. Primary cosmic rays consist mostly of

(a) protons ( )

(b) pions ( )

(c) kaons ( )

(d) muons ( )

10. Leptons are not affected by

(a) weak force ( )

(b) strong force ( )

(c) electromagnetic force ( )

(d) gravitational force ( )

(SECTION : B—SHORT ANSWERS)

(*Marks* : 15)

Answer the following questions : 3×5=15

UNIT—I

1. Deduce Newton's law of gravitation from Kepler's law of planetary motion.

OR

2. For a two-body problem under the influence of central force, obtain the equation of motion as a one-body problem using reduced mass.

UNIT—II

3. Obtain the equation for radioactive decay law. Hence, establish the relationship between half-life and decay constant.

OR

4. Write the four-factor formula (infinite multiplication factor), and briefly explain the significance of each term.

UNIT—III

5. Mention the advantages and disadvantages of graphite as moderator in a nuclear reactor.

OR

6. What do you understand by *p-p* cycle? Describe the steps involved in the cycle, providing the equations in each step.

UNIT—IV

7. Write a brief explanation on the working principle and application of a scintillation counter.

OR

8. What are the significances of using particle accelerators? Why are particles needed to be accelerated?

UNIT—V

9. Write a short note on Bhabha-Heitler theory of electron showers.

OR

10. Mention the developmental steps of cosmic-ray air showers.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

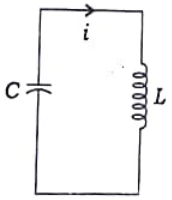
Answer the following questions : 10×5=50

UNIT—I

1. Find the centre of mass of a rod of length L having linear mass density $\lambda(x) = e^{-\lambda_0 x} / L$, where λ_0 is a constant coefficient of length.

OR

2. For the L-C circuit given below—



(a) write the Lagrangian;

(b) obtain the Lagrange's equation of motion;

(c) find the corresponding Hamiltonian from the Lagrangian;

(d) obtain the Hamiltonian equations of motion.

UNIT—II

3. With suitable illustrative block diagram, describe the method of gamma ray detection using gamma spectrometer or crystal spectrometer.

OR

4. Answer the following regarding alpha decay :

   (a) Who discovered it?

   (b) How does it happen?

   (c) In what type of nuclei (in terms of N / Z ratio), it mostly occurs?

   (d) Write the equation for X nucleus decaying into Y nucleus. Obtain the expression for Q-value of the equation.

UNIT—III

5. Mention the main features of the liquid drop model. Discuss in detail the corrections that eventually lead to the semi-empirical mass formula.

OR

6. Explain the origin of stellar energy. Discuss, in detail, with suitable equations, the complete process of CNO cycle.

UNIT—IV

7. Give a brief account of the major particle accelerators in India. Describe, in detail, the construction, the working principle of a Van de Graaff generator. Also, highlight its disadvantages.

OR

8. Discuss the principle and components of an ionization chamber, mentioning its limitation. Explain the concept of saturation current and its function.

UNIT—V

9. Describe, in detail, how the intensity of cosmic radiation is affected by the altitude, latitude and East-West effects.

OR

10. Answer the following regarding quarks :

(a) What are quarks? Mention the different types of quarks.

(b) Highlight the nature of quark-quark interaction.

(c) Discuss briefly their electrical properties and their strangeness.

(d) Why are they regarded as fundamental particles?

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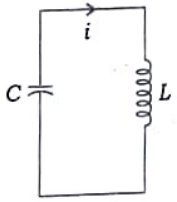

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