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(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)

Tick (✓) the correct answer in the brackets provided : 1×10=10

1. For a diatomic molecule in 3 dimension, the degrees of freedom is

(a) 2 ( )

(b) 5 ( )

(c) 7 ( )

(d) 6 ( )

2. For a conservative system, Hamiltonian is (T = kinetic energy, V = potential energy)

(a) $H \quad T \quad V$ ( )

(b) $H \quad T \quad V$ ( )

(c) $H \quad 2T \quad V$ ( )

(d) $H \quad 2T \quad V$ ( )

3. Nuclei of the same element having different number of neutrons are called

(a) atomic numbers ( )

(b) isobars ( )

(c) isotopes ( )

(d) mass numbers ( )

4. As a result of radioactive decay, a $_{92}U^{238}$ nucleus is changed into $_{91}Pa^{234}$ nucleus. The particles emitted are

(a) one particle and one particle ( )

(b) one particle and two particles ( )

(c) two particles ( )

(d) two particles ( )

5. Complete the nuclear reaction

$$^{9}Be_{4} \quad \text{———} \quad ^{12}C_{6} \quad ^{1}n_{0}$$

(a) $^{4}He_{2}$ ( ) *(b)* $^{1}H_{1}$ ( )

(c) $^{7}Li_{3}$ ( ) *(d)* -particles ( )

6. According to Rutherford's alpha particle scattering experiment

(a) atom is almost empty ( )

(b) nucleus is having very high density ( )

(c) nucleus is having positive charge ( )

(d) nucleus is neutral ( )

7. For Cherenkov radiation to be emitted, the velocity of the charged particle v should be

(a) $v \quad \frac{n}{c}$ ( ) *(b)* $v \quad \frac{n}{c}$ ( )

(c) $v \quad \frac{c}{n}$ ( ) *(d)* $v \quad nc$ ( )

8. A GM counter collects 108 electrons per discharge when the counting rate is 500 counts per minute. What will be the average current in the circuit?

(a) 1 75 10 ^{10} A ( )

(b) 1 33 10 ^{10} A ( )

(c) 2 10 ^{10} A ( )

(d) 1 0 10 ^{10} A ( )

9. Hyperons are particles which are

(a) heavier than proton ( )

(b) lighter than proton ( )

(c) same mass as proton ( )

(d) lighter than electron ( )

10. Lepton number for proton is

(a) +1 ( )

(b) –1 ( )

(c) 0 ( )

(d) +1/2 ( )

(SECTION : B—SHORT ANSWER)

(*Marks* : 15)

Answer the following : 3×5=15

UNIT—I

1. Obtain Lagrangian for simple pendulum.

OR

2. Show that square of the time period of a planet around the sun proportional to the cube of the semimajor axis.

UNIT—II

3. Write a short note on Geiger-Nuttall law.

OR

4. Calculate the average binding energy per nucleon of nuclear mass 15·994916 u. (Given : m_p 1 007825 u, m_n 1 008665 u)

UNIT—III

5. What do you mean by nuclear fission? Explain it with giving one reaction as an example.

OR

6. Write a short note on magic numbers.

UNIT—IV

7. Describe in brief the working of ionization chamber.

OR

8. How does photomultiplier tube multiply signal?

UNIT—V

9. Check the feasibility of the following reaction :

$$p \quad p \quad n \quad p$$

OR

10. Write a short note on strangeness of elementary particles.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following : 10×5=50

UNIT—I

1. What do you mean by central force? Show that angular momentum is conserved in central force motion. Show that the equation of orbit in central force is given by

$$\frac{d^2u}{d^{\ 2}} \quad u \qquad \frac{m}{J^2u^2}F \quad \frac{1}{u}$$

where the symbols have their usual meanings. 1+2+7=10

OR

2. *(a)* Obtain Lagrange equation of motion from d'Alembert's principle. 6

(b) What is Hamiltonian? Show that Hamiltonian is given by

$$H \qquad \dot{q}_j p_j \quad L$$ 4

UNIT—II

3. What is quadrupole moment? Derive an expression for quadrupole moment of a nucleus. Show that the smallest value of angular momentum I for which the quadrupole moment does not vanish, is one. 10

OR

4. Obtain the Weizsäcker's semiempirical mass formula. Describe each term and explain their physical significance. 10

UNIT—III

5. *(a)* State the basic properties of neutron and its classification. 5

(b) Give an account of the discovery of neutron. Classify neutrons according to their kinetic energy. 2+3=5

OR

6. *(a)* Discuss Bohr-Wheeler theory of nuclear fission. 4

(b) Calculate the *Q*-value of the following reaction : 2

$$_3Li^6 \quad _0n^1 \quad _1H^3 \quad _2He^4$$

Given masses (in a.m.u.) of $_3Li^6$ 6 015123, $_0n^1$ 1 008665, $_1H^3$ 3 016029, $_2He^4$ 4 002603.

(c) Calculate the energy that can be obtained from a 47 kg of $_{92}U^{235}$. If this energy is to be used for one year (365 days), then how much power (in MW) can be obtained from it throughout the year? [Given : one fission of $_{92}U^{235}$ gives 200 MeV, Avogadro's number = 6 023 10^{23} and 100% efficiency.] 4

UNIT—IV

7. Explain the construction and working principle of proportional counter. What kind of charges can it detect? 10

OR

8. What do you mean by accelerators? Describe the construction and working of cyclotron. What are the limitations of cyclotron? 10

UNIT—V

9. State and explain with examples the conservation laws which govern the elementary particle reactions and decays. 10

OR

10. *(a)* What are quarks? Write down six different quarks with their quantum numbers. 1+3=4

(b) Write a note on Bhabha's theory of electron showers. 6

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