2018

(6th Semester)

PHYSICS

TENTH PAPER

(Nuclear Physics—II)

(Revised)

Full Marks : 75

Time : 3 hours

(PART : A—OBJECTIVE)

(*Marks* : 25)

The figures in the margin indicate full marks for the questions

SECTION—A

(*Marks* : 10)

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

1. In the semiempirical binding energy formula of a nucleus, which of the following energies is positive?

(a) Asymmetry energy ( ) *(b)* Volume energy ( )

(c) Coulomb energy ( ) *(d)* Surface energy ( )

2. Which of the following pairs are mirror nuclei?

(a) $_6C^{13}$ and $_6C^{14}$ ( ) *(b)* $_7N^{14}$ and $_6C^{14}$ ( )

(c) $_4Be^7$ and $_3Li^7$ ( ) *(d)* $_5B^{10}$ and $_4Be^8$ ( )

3. The mass of a deuteron (m_D) 2 01335 a.m.u., mass of a proton (m_p) 1 00728 a.m.u. and mass of a neutron (m_n) 1 00866 a.m.u. The binding energy of a deuteron is nearly [Given , 1 a.m.u. = 931 MeV]

(a) 2·23 MeV ( ) *(b)* 1·22 MeV ( )

(c) 1·12 MeV ( ) *(d)* 28·1 MeV ( )

4. The decay constant ( ) is defined as the reciprocal of time during which the number of atoms of a radioactive substance falls to

(a) $\frac{1}{2}$ of its original value ( ) *(b)* $\frac{1}{3}$ of its original value ( )

(c) $\frac{1}{4}$ of its original value ( ) *(d)* $\frac{1}{e}$ of its original value ( )

5. According to nuclear shell model, the total angular momentum of $_8O^{16}$ is

(a) $\frac{5}{2}$ ( ) *(b)* $\frac{3}{2}$ ( )

(c) $\frac{1}{2}$ ( ) *(d)* zero ( )

6. The threshold energy is applicable only for

(a) exoergic reactions ( ) *(b)* endoergic reactions ( )

(c) exothermic reactions ( ) *(d)* all nuclear reactions ( )

7. Which of the following particles can be accelerated in a cyclotron?

(a) Electron ( ) *(b)* Neutron ( )

(c) Proton ( ) *(d)* All of the above ( )

8. If 2000 particles are passing through the GM counter in a given time and 1500 are recorded in the same time, then efficiency of the counter is

(a) 75% ( ) *(b)* 50% ( )

(c) 30% ( ) *(d)* 15% ( )

9. The primary cosmic radiations approaching the earth's atmosphere contains mainly

(a) protons and -particles ( )

(b) electrons and -particles ( )

(c) protons and -mesons ( )

(d) electrons, positrons and photons ( )

10. Which of the following quarks is positively charged?

(a) Strange (s) ( ) *(b)* Bottom (b) ( )

(c) Charm (c) ( ) *(d)* Down (d) ( )

SECTION—B

(*Marks* : 15)

Answer the following questions : 3×5=15

1. Mention at least three important properties of nuclear forces.

2. Show that the binding energy per nucleon for -particle of Helium nucleus ($_2He^4$) is 7·04 MeV. Given masses m_p 1 007276 a.m.u., m_n 1 008665 a.m.u., M 4 001506 a.m.u. and 1 a.m.u. = 931 MeV.

3. Calculate the Q-value of the following nuclear reaction in MeV : $_3Li^7$ $_1H^1$ $_2He^4$ $_2He^4$. Given that masses of $_3Li^7$ 7 018222 a.m.u., $_1H^1$ 1 008144 a.m.u. and $_2He^4$ 4 003873 a.m.u. Comment whether the energy is released or absorbed in this reaction.

4. What is the main limitation of a cyclotron and how this problem is solved in synchrotron and synchrocyclotron?

5. What are hadrons? Explain with examples how these are classified based on quark structure.

(PART : B—DESCRIPTIVE)

(*Marks* : 50)

The figures in the margin indicate full marks for the questions

1. *(a)* Define isotope, isobar and isotone and give example of each. 3

(b) Show that the nuclear density is constant and of the order of 10^{17} kg.m ^{3} for all nuclei. Mention a celestial object having density of same order. 3+1=4

(c) Write a short note on nuclear stability with reference to neutron-proton ratio. 3

OR

(a) Define binding energy of a nucleus and write its expression. Explain why the surface effect reduces the binding energy by E_s $bA^{2/3}$, where A is the mass number and b is a constant. 2+2=4

(b) "The electrostatic repulsion between each pair of protons in a nucleus also contributes towards reducing its binding energy." Explain this statement and find the expression of Coulomb energy E_C. 2

(c) Draw a curve of binding energy per nucleon in MeV as a function of mass number A and discuss its significance in explaining nuclear fission and fusion. 2+2=4

2. *(a)* Derive the exponential decay law of a radioactive substance. Hence show that the half-life T 0 693 , where is the decay constant. 4+2=6

(b) Define mean-life (T_m) of a radioactive substance and hence show that T_m 1 44T. 1+3=4

OR

(a) Discuss three different types of -decay with representative reactions and examples. 6

(b) What conservation laws must be followed by -ray emission from a radioactive substance? What do you mean by nuclear isomerism? 3+1=4

3. *(a)* State the main assumptions of nuclear shell model and mention the experimental evidences in favour of it. 3

(b) Based on the level schemes of single-particle shell model, show that the total angular momentum of the nucleus of $_8O^{17}$ is $\frac{5}{2}$. 2

(c) What do you mean by threshold energy and Q-value of a nuclear reaction? Establish the relation between these. 2+3=5

OR

(a) Explain how the Bohr-Wheeler theory accounts for various properties of nuclear fission. 5

(b) What is fusion reaction? Give an example. Why is it called thermonuclear reaction? 2

(c) Write a short note on nuclear reactor. 3

4. *(a)* Describe the construction and working of a linear accelerator. What are its limitations? 4+2=6

(b) Discuss the construction and working of a proportional counter. Why is the device so named? 3+1=4

OR

Write short notes on any *two* of the following : 5×2=10

(a) Betatron

(b) Synchrocyclotron

(c) Geiger-Müller counter

(d) Wilson cloud chamber

5. *(a)* What are primary and secondary cosmic rays? Discuss 'east-west effect' to explain that primary cosmic rays carry mainly positively charged particles. 2+3=5

(b) Describe with schematic diagrams, Bhabha's theory of cosmic-ray showers. 5

OR

(a) What are leptons and anti-leptons? Mention the names of all leptons with their charge and lepton numbers. Show that the lepton numbers remain conserved in the following neutron decay process :

$$n \quad p \quad e \quad \bar{\nu}_e$$

where p is proton, e is electron and $\bar{\nu}_e$ is anti-neutrino. 2+2+1=5

(b) What do you mean by baryon number (B), hypercharge (Y) and strangeness (S)? Mention the relation among those and verify the relation for neutron. 3+2=5

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