6 SEM TDC PHY M 3

2017

(May)

PHYSICS

(Major)

Course : 603

(Nuclear Physics)

Full Marks : 60
Pass Marks : 24/18

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the following (any *five*) : 1×5=5

(a) The resultant angular momentum of a nucleus is called

(i) nuclear momentum

(ii) nuclear magnetic moment

(iii) nuclear spin

(iv) nuclear quadrupole moment

(b) The average number of neutrons released by the fission of one uranium atom is

(i) 2·5

(ii) 3

(iii) 1

(iv) 2

(c) As the mass number *A* increases, which of the following quantities related to the nucleus does not change?

(i) Binding energy

(ii) Density

(iii) Volume

(iv) Mass

(d) The neutrons released in a fission process are

(i) slow neutrons only

(ii) prompt neutrons only

(iii) delayed neutrons only

(iv) prompt and delayed neutrons

(e) Liquid-drop model predicts

(i) depth of net nuclear potential asymmetry term

(ii) magic numbers, nuclear spins, nuclear particles and pairing term

(iii) electric quadrupole moment

(iv) accurate average masses and binding energies through semi-empirical mass formula

(f) The formation of cosmic ray showers is based upon the phenomenon of

(i) emission

(ii) pair production

(iii) reflection

(iv) refraction

2. Answer any *five* of the following questions : 2×5=10

(a) Calculate the mass of deuterium nucleus if the binding energy per nucleon is 1 MeV (given $m_p = 1 \cdot 00758$, $m_n = 1 \cdot 00898$).

(b) What are the physical quantities that are not conserved in nuclear reactions?

(c) What is the need of a particle accelerator? Why can a cyclotron not be used to produce high energy electron beams?

(d) How are nuclear forces different from other kinds of forces?

(e) "Nuclear reactions prove to be a source of energy." Justify the statement.

(f) What are elementary particles? Write the names of various categories of the known elementary particles.

3. What is nuclear cross-section (σ)? Establish an expression for σ in terms of n (number of particles per unit volume), N (total number of interacting particles), dN (number of interacting particles), etc. 1+3=4

Or

Calculate the mass number of the nucleus where radius is 2·17 fm (given $R_0 = 1 \cdot 5$ fm). 4

4. What are mirror nuclei? Give a few examples. Write the evidences that establish the shell structure within nuclei. Point out successes of shell structures. 1+1+3+2=7

Or

Discuss briefly the liquid-drop model of nucleus. Point out its usefulness and limitations in understanding nuclear phenomena. 2+3+2=7

5. What do you mean by induced radioactivity? How can stable nuclei be made radioactive? Write one alpha induced and one proton induced reaction. What are the physical quantities that are conserved in nuclear reactions? 1+2+2+2=7

Or

What are nuclear transformations? Why is high energetic projectile required for a nuclear transformation? What is *Q*-value of a nuclear reaction? What is its significance? Find the *Q*-value of the following reaction : 1+1+1+1+3=7

$$_7N^{14} + {}_2He^4 \rightarrow {}_8O^{17} + {}_1H^1 + Q$$

Given, the atomic masses are

$$_7N^{14} = 14 \cdot 00755u, \quad {}_2He^4 = 4 \cdot 00388u$$

$$_8O^{17} = 17 \cdot 00453u \text{ and } {}_1H^1 = 1 \cdot 00815u$$

6. What are the various methods of determining the size of the nucleus? Describe any one of them. 2+5=7

Or

How is stability of a nucleus related with binding energy of the nucleus? Calculate the binding energy per nucleon in $_6C^{12}$. 7

(Given that $m_H = 1 \cdot 007825u$, $m_n = 1 \cdot 008665u$, mass of $_6C^{12}$ atom $m = 12 \cdot 00000u$ and $1u = 931$ MeV).

7. Discuss briefly the classification of elementary particles and state their main characteristics. 4+2=6

Or

Discuss the different types of interactions among elementary particles. Give a comparative analysis of them in terms of their relative strength, range and exchange particles. 4+2=6

8. What are cosmic ray showers? Give a brief account of the origin of cosmic rays. 2+3=5

(Continued)

9. Write short notes on (any *three*) : 3×3=9

(a) Mass defect and packing fraction

(b) Cyclotron

(c) Nuclear chain reaction

(d) van de Graaff generators

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