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6 SEM TDC DSE PHY (CBCS) 1 (H)

2022

(June/July)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–1

(Nuclear and Particle Physics)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×5=5

(a) Which of the following elements possessing the highest value of binding energy per nucleon?

(i) Gold

(ii) Uranium

(iii) Iron

(iv) Mercury

(b) Nuclei having which of the following numbers of protons and neutrons are remarkably stable?

(i) 2, 8, 16, 28

(ii) 2, 8, 20, 28

(iii) 2, 8, 16, 20

(iv) None of the above

(c) Which of the following statements is correct?

(i) Beta rays are electromagnetic radiation.

(ii) Alpha rays are positively charged particles but beta and gamma rays are electromagnetic radiation.

(iii) Alpha rays are positively charged particles but beta rays are negatively charged particles and gamma rays are electromagnetic radiation.

(iv) None of the above

(d) The lepton number for a neutron is

(i) 1

(ii) −1

(iii) 0

(iv) None of the above

(e) The parity is violated in

(i) all elementary interactions

(ii) strong interactions

(iii) weak interactions

(iv) None of the above

2. (a) What is parity of a nucleus? 1

(b) Calculate the mass defect, binding energy and binding energy per nucleon for a lithium nucleus ($_3Li^7$), if

mass of the nucleus = 7·0 a.m.u.
mass of proton = 1·007825 a.m.u.
mass of neutron = 1·008665 a.m.u.
1 a.m.u. = 931·5 MeV 3

Or

Explain the term 'nuclear magnetic dipole moment'.

(c) Discuss the conclusions drawn from the graph between the binding energy per nucleon and mass number. How can release of energy in fission and fusion be explained from this graph? 3+2=5

3. (a) Discuss briefly the nature of nuclear force. 3

(b) Write down the semiempirical mass formula, describing the significance of each term. 4

(c) Discuss the evidences behind the shell structure of the nucleus. Give a qualitative description of the shell model of the nucleus. 3+3=6

4. (a) Find the half-life of $_{92}U^{238}$, if one gram of it emits $1{\cdot}24\times10^{4}$ alpha-particles per second. (Avogadro's number = $6{\cdot}025\times10^{23}$) 3

Or

Deduce the law of radioactive disintegration. What is 'half-life' of a radioactive material? 2+1=3

(b) Describe briefly the Geiger-Nuttal law for alpha particles. 2

(c) What is neutrino? Describe how the neutrino hypothesis could explain the continuous energy spectrum of beta decay. 1+3=4

5. (a) Describe the conservation laws followed by nuclear reactions. 3

(b) Discuss the compound nucleus theory of nuclear reaction. 3

(Continued)

(c) Calculate the energy released in the reaction

$$_3Li^6 + _0n^1 \rightarrow _2He^4 + _1H^3 + Q$$

if $m(_3Li^6) = 6 \cdot 015126\,u;$

$m(_0n^1) = 1 \cdot 0086654\,u;$

$m(_2He^4) = 4 \cdot 0026044\,u;$

$m(_1H^3) = 3 \cdot 016049\,u.$ 3

Or

Derive a relation for nuclear reaction cross section.

6. Write short notes on any *two* of the following : 4×2=8

(a) Synchrotron radiation

(b) Bethe-Bloch formula

(c) Interaction of gamma ray with matter

7. Describe the principle and working of a Geiger-Müller counter. What is recovery time? What is 'quenching' and how can it be achieved? 4+2+1+2=9

Or

What are semiconductor particle detectors? What is its advantage over gas-filled detectors? Describe the theory and working of any one type of semiconductor particle detector. 1+2+3+3=9

8. Describe the principle and working of a linear accelerator. What are the disadvantages in using this accelerator? 4+1=5

Or

What are cyclic accelerators? What are the advantages of using a cyclic accelerator? Describe briefly the working of any one type of cyclic accelerator. 1+1+3=5

9. *(a)* What are fundamental interactions in nature? Give a comparison between the fundamental interactions. 1+3=4

(b) What are isospin of an elementary particle? Describe briefly the Gell-Mann-Nishijima scheme for elementary particles. 1+2=3

(c) What do you mean by strange particles? What is strangeness quantum number? 2+1=3

(d) Describe the classification of elementary particles on the basis of the standard model. 3

Or

What are quarks? Give the quark structure of protons and neutrons.

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