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

2023

(May/June)

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 option from the following : 1×5=5

(a) With increase in mass number, the neutron to proton ratio

(i) increases

(ii) decreases

(iii) increases first and then decreases

(iv) None of the above

(b) Neutrons have a _____ value of dipole magnetic moment.

(i) positive

(ii) negative

(iii) zero

(iv) None of the above

(c) In alpha decay

(i) mass number A decreases by 4 and atomic number Z increases by 2

(ii) mass number A decreases by 4 and atomic number Z decreases by 2

(iii) mass number A increases by 4 and atomic number Z decreases by 2

(iv) mass number A increases by 4 and atomic number Z increases by 2

(d) Electron is a _____ generation particle.

(i) first

(ii) second

(iii) third

(iv) None of the above

(e) Isospin is to be conserved in

(i) all elementary interactions

(ii) strong interactions only

(iii) weak interactions only

(iv) None of the above

(Continued)

2. (a) What is nuclear quadrupole moment? 1

(b) Write down the relation between mass number and radius of a nucleus. Describe a method for determining nuclear radius. 1+3=4

Or

Explain the terms 'nuclear angular momentum' and 'nuclear quadrupole moment'. 2+2=4

3. (a) What are magic numbers? What is their significance in the shell model of the nucleus? 1+2=3

(b) What are the applications of the semi-empirical mass formula? Draw a graph indicating the contribution of the various terms of the semi-empirical mass formula to the total binding energy. 2+2=4

(c) Describe the liquid-drop model of the nucleus describing the similarities of the nucleus with a drop of liquid. How can nuclear fission be explained on the basis of this model? 4+2=6

(Turn Over)

4. (a) Describe how the range of alpha particles can be determined. What is straggling? Write down the relation connecting range and disintegration constant. 3+1+1=5

(b) Write down the equation showing the three modes of beta radioactivity. Describe the role of neutrino in explaining continuous energy spectrum of beta particles. 1+3=4

5. (a) Discuss Rutherford scattering in a nucleus. 3

(b) Derive an expression for Q-value of a nuclear reaction. 3

(c) A 7·7 MeV alpha particle interacts with a target nucleus $^{14}_{7}N$ to produce a residual nucleus $^{17}_{8}N$ and a product particle $^{1}_{1}H$. The protons emitted at 90° to the incident beam direction are found to have kinetic energy of 4·44 MeV. Calculate the Q-value of the reaction. 3

Or

Differentiate between direct reaction and compound nucleus reaction.

(Continued)

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

(a) Cerenkov radiation

(b) Photoelectric effect

(c) Interaction of neutron with matter

7. What are the gas filled detectors? Describe briefly how gas filled detectors work in the following different regions on varying the plate voltage : 1+2+3+3=9

(a) Ionization chamber region

(b) Proportional region

(c) Geiger region

Or

Describe the principle and working of a scintillation detector. Name any two scintillators. Describe the working of a photomultiplier tube. 4+2+3=9

8. Describe the working of a cyclotron. How are the difficulties faced in a cyclotron removed in a synchrotron? 3+1+1=5

Or

What are tandem accelerators? Describe the construction and working of a van de Graaff generator. 2+3=5

(Turn Over)

9. (a) What is strong interaction? What are the conservation laws to be satisfied in strong interaction? What is the associated exchange particle? 1+2+1=4

(b) What does generation mean in particle physics? Which particles are the first-, second- and third-generation leptons? 1+3=4

(c) What are hadrons? Which fundamental interaction is specific to them? 2+1=3

(d) Check whether isospin and strangeness are conserved in the following reactions : 2×3=6

(i) $\pi^+ + n \rightarrow \pi^- + p$

(ii) $\pi^- + p \rightarrow \Lambda^\circ + K^\circ$

(iii) $\pi^+ + \Lambda^\circ \rightarrow \Sigma^+ + K^\circ$

Or

What are quarks? Give the quark structure of pions. 3+3=6

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