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

2025

(May)

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)　The magic numbers are

    　　(i) 2, 8, 16, 28, 64, 86, 128

    　　(ii) 2, 8, 20, 28, 50, 82, 126

    　　(iii) 2, 8, 16, 48, 64, 56, 128

    　　(iv) None of the above

　　　　　　　　　　(Turn Over)

(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) A decreases by 4 and Z decreases by 2

   (iii) A increases by 4 and Z decreases by 2

   (iv) A increases by 4 and Z increases by 2

(d) A neutrino is a _____ generation particle.

   (i) 1st

   (ii) 2nd

   (iii) 3rd

   (iv) None of the above

(e) If Y is the hypercharge, B the baryon number, S the strangeness of a particle, then

   (i) $S = (Y + B)/2$

   (ii) $Y = (B + S)/2$

   (iii) $Y = (B - S)/2$

   (iv) None of the above

2. Show that nuclear density is a constant. Describe briefly a method for determination of nuclear radius.   2+3=5

Or

What are mass defect, mass loss and packing fraction for a nucleus? Find the binding energy of $^{64}_{28}Ni$ if the mass of an atom is $63 \cdot 927958$ u, $m_n = 1 \cdot 008665$ u and $m_H = 1 \cdot 007825$ u.   3+2=5

3. (a) Describe the variation of binding energy per nucleon with mass number. What do the local maxima in the curve indicate?   3+2=5

(b) Describe briefly the contribution of each term of the semi-empirical mass formula to the total binding energy. Write any two uses of the semi-empirical mass formula.   2+2=4

(c) Describe the similarities of the nucleus with a drop of liquid. Give two dissimilarities between the two. 3+2=5

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) Describe how Pauli's neutrino hypothesis explained the energy spectrum for beta rays. 4

5. (a) Describe compound nucleus reaction with example. 3

(b) What is meant by cross-section of nuclear reaction? What are 'partial cross-section' and 'differential cross-section'? 3

(c) A 7·7 MeV α-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

(Continued)

Or

Derive the relation for Q-value of a nuclear reaction.

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

   (a) Bethe-Bloch formula

   (b) Cherenkov radiation

   (c) Interaction of neutron with matter

7. What are gas-filled detectors? Name any two types of gas-filled detector. Describe the construction and working of a proportional counter with a neat diagram. What is multiplication factor?   2+2+4+1=9

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. Derive the relation between frequency of the applied radio frequency voltage and applied magnetic field in a cyclotron.   3+2=5

Or

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

9. (a) What is the meson theory of nuclear force? Compare the four fundamental interactions in terms of strength, exchange particle and range. 1+3=4

(b) What does 'generation' mean in particle physics? Which particles are the 1st, 2nd and 3rd generation leptons? 1+2=3

(c) Which particles constitute vector boson? What is their role in fundamental interactions? 2+1=3

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

(i) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(ii) $\bar{n} \rightarrow \bar{p} + e^+ + v_e$
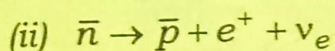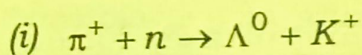
Or

What are quarks and gluons? Give the quark composition of the following : 2+4=6

   (i) Neutron

  (ii) Proton

 (iii) Antiproton

 (iv) Neutral pion

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