4/11/19 M

[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 7954 **J**

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

Name of the Course : **B.Sc. (Hons.) Physics : DSE–1**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all. Question No. **1** is compulsory.
3. **All** questions carry equal marks.
4. Use of Scientific Calculator is allowed.

1. Attempt any **five** : (3×5=15)

   (a) State basic assumptions of the Shell Model.

   (b) How does the nuclear charge density distribute from the nuclear centre to the nuclear surface?

P.T.O.

(c) Differentiate between internal conversion and internal pair conversion.

(d) Explain why in the photoelectric effect, the incident photon interacts with the inner shell electrons?

(e) What is Townsend Avalanche?

(f) Assign the isospin quantum number (I, I_3) to pionic triplet.

(g) 10 milligrams of a radioactive material of half life period two years are kept in store for four years. How much of the material remains unchanged?

(h) Why free neutron does not decay into an electron and a positron?

2. (a) What is Binding Energy? Represent graphically the variation of average binding energy per nucleon with the mass number A. Indicate the stable and unstable regions due to fusion and fission. (1+2+2=5)

(b) A 5 MeV α-particle approaches a Gold (Z=79) nucleus with an impact parameter of 2.6×10^{-13} m, through what angle will it be scattered? (5)

(c) Define nuclear cross-section. The cross section and the number of atoms per cubic meter for ^{113}Cd for capturing thermal neutrons are 2×10^{-24} m^2 and 5.58×10^{27} atoms/m^3 respectively. What is the thickness of cadmium needed to absorb 99 percent of an incident beam of thermal neutrons? (2+3=5)

3. (a) Consider a nucleus with mass number, A. Use the semi-empirical mass formula to find the atomic number (Z) for the most stable isobar nucleus for this A. (Given coulomb coefficient, $a_3 = 0.7053$ MeV and asymmetry energy coefficient, $a_4 = 23.702$ MeV). Identify the stable nucleus from the nuclei : $^6He_2$, $^6Be_4$, $^6Li_3$. (5+3=8)

(b) Estimate the Fermi energies of neutrons and protons in centre of ^{238}U. Assume density of nuclear matter in the centre of ^{238}U nucleus to be 2×10^{38} nuclei/cm^3. (7)

4. (a) What are the basic assumptions of Gamow's theory of alpha decay? Calculate the collision frequency of an alpha particle that knocks at its nuclear wall with the velocity 2×10^7 m/s. (3+2=5)

P.T.O.

(b) What led Pauli to propose a neutrino to explain the observed beta decay? Why is beta decay called isobaric transformation? (4+1=5)

(c) Differentiate between the alpha particle spectrum and beta particle spectrum. (5)

5. (a) How do the heavy charged particle and the gamma rays interact with matter? (5)

(b) What is Cerenkov radiation? Calculate the β-energy for which radiation losses and ionization losses are equal in Pb (Z=82). (5)

(c) X-rays of wavelength 10.0 pm are scattered from a target. Find the maximum kinetic energy of the recoil electrons. (5)

6. (a) What is the working principle of an ionization chamber? Find the current produced by the ionization chamber if the source is emitting 10^4 particles/sec and 10^5 ion-electron pairs are produced in the gas. (3+2=5)

(b) What is a scintillation detector? Discuss the working principle of a photo multiplier tube. (2+3=5)

(c) The applied potential across the Dees of the cyclotron is 20 keV and subjected to a transverse magnetic field of 1.1 Tesla is used to accelerate the protons. Find the maximum energy acquired by the protons if these accelerated protons are extracted from the Dees at a radius of 28 cm from the centre of the Dees. (5)

7. (a) What are Weak interactions? Give any three examples. (2+3=5)

(b) Determine whether the following reactions are allowed or forbidden. (3+3=6)

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

(ii) $p + p \rightarrow K^+ + \Sigma^+$

(c) Find the charge number, baryon number and strangeness of a particle described by the quark structure (sss). Identify the particle. (4)

P.T.O.

PHYSICAL CONSTANTS

$m_p = 1.007825$ u, $m_n = 1.008665$ u

$m_e = 0.00055$ u, $m_{He} = 2.0141$ u

1 amu $= 1.66 \times 10^{-27}$ kg, $R_0 = 1.2$ fm

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m, $h = 6.6 \times 10^{-34}$ Js

$c = 3 \times 10^8$ m/s, 1 eV $= 1.6 \times 10^{-19}$ J