Your Roll No…….

Unique Paper Code :32227504

Name of the Paper : Nuclear and Particle Physics

Name of the Course : **B.Sc. (Hons.) Physics-CBCS-DSE**

Semester : **V**

Duration: **3Hours** Maximum Marks: **75**

All questions carry equal marks.

Attempt four questions in all.

Use of Scientific Calculator is allowed.

1. Discuss the Fermi model for the nuclear charge distribution. Show that the nuclear density is the same for all the nuclei. (3+3=6)

   What is the significance of average binding energy? Draw the average binding energy versus mass number curve. Indicate the stable and unstable regions due to fusion and fission. (2+2+2=6)

   The radii of A and B nuclei are found to be 3.46 fm and 7 fm respectively. Their masses are given as 4.1×10^{-26} kg and 3.4×10^{-25} kg respectively. Calculate the ratio of their densities. (2+2+0.75=4.75)

   The electronic structure is known before the nuclear structure. Explain why? (2)

2. What are the nuclear magic numbers? Write the basic assumptions of nuclear shell model. (1+4=5)

   Mention and relate the dependence of the various factors that contribute to the semiempirical binding energy (BE) formula. Consider a nucleus with mass number, A. Use this semiempirical BE formula to find the atomic number (Z) for the most stable

isobar nucleus for this A. Identify the stable nucleus from these light nuclei: $^{6}He_{2}$, $^{6}Li_{3}$, $^{6}Be_{4}$. (Given a_3=0.7053MeV and a_4=23.702MeV) (2.5+4+2.25=8.75)

Name a nuclear model which falls in the category of an independent particle model. Calculate the Fermi momentum and Fermi energy of a nucleus with N=Z=A/2. (1+2+2=5)

3. State the basic assumptions of Gamow's theory of alpha decay. Write down the equation and discuss the successful of this theory. Represent the Geiger Nuttall law graphically. What is the importance of this empirical law? (3+1+2 +1+1=8)

   Why is the beta decay called the isobaric transformation? Explain the continuous beta particle energy spectrum. Show that for the spontaneous electron emission, the mass of the parent atom is greater than the mass of the daughter atom. (1+3+3=7)

   When does a nucleus undergo gamma decay? State the basic difference between internal conversion and photoelectric effect and also between internal pair conversion and pair production. (1.75+1+1=3.75)

4. Write the Chadwick's nuclear reaction which led to the discovery of neutron. On which basis nuclear reactions are classified? State the differences between radiative capture nuclear reactions and compound nuclear reactions. (1+0.75+4=5.75)

   What is the threshold energy of a projectile of nuclear reactions? Estimate the threshold energy of the projectile in terms of the Q value of the nuclear reaction, mass of the target nucleus and mass of the projectile. (1+5=6)

   Define nuclear reaction cross-section. In what unit it is measured? The cross section and the number of atoms per cubic meter for cadmium, ^{113}Cd for capturing thermal neutrons are 2×10^{-24} m^2 and 5.58×10^{27}atoms/m^3 respectively. What thickness of cadmium is needed to absorb 99 percent of an incident beam of thermal neutrons? Is cadmium an efficient absorber of thermal neutrons? (2+1+ 3+1=7)

5. How do the gamma rays and neutrons interact with matter? Distinguish between the Bremsstrahlung radiation and Cerenkov radiation. Calculate the threshold velocity of electrons to produce Cerenkov radiation in a medium of refractive index 1.52. (2+2+2=6)

Compare the photoelectric effect and Compton scattering in terms of the interactions between the incident photons and the target matters. (3)

Explain the construction and working of an ionization chamber for nuclear radiation detection. Alpha particles of energy 3.5MeV are the incident radiations of the ionization chamber. Calculate the current in the ionization chamber circuit if the source is emitting about 10^4 alpha particles/sec. (Given, the w-value of the gas in the detector chamber=35eV) (2.5+2.5+2=7)

What are the advantages offered by the semiconductor detectors over gas filled or scintillation detectors? (2.75)

6. Give the Lepton and Baryon numbers for electrons, protons and neutrons. (3)

   Plot the Baryon octet based on the quark mode on the charge strangeness axes. State the quantum numbers of all the particles in the octet. (4)

   Explain which of the following reactions are allowed or forbidden under the conservation of strangeness, conservation of Lepton number, conservation of Baryon number, conservation of charge, conservation of hypercharge and conservation of third component of isospin.

   (i) $\Lambda^0 \rightarrow \pi^+ + \pi^-$

   (ii) $p + p \rightarrow p + \Lambda^0 + \Sigma^+$ (3+3=6)

   State the principle of a cyclotron. A cyclotron with the applied potential of 20KeV across the dees of radius of 28 cm is subjected to a transverse magnetic field of 1.1 Tesla. Calculate the energy to which a proton can be accelerated. Why the cyclotrons cannot be used to accelerate electrons? (2+2+1.75=5.75)

Useful data:

mass of the proton=1.67×10^{-27} kg; charge of an electron=1.602×10^{-19} C; r_0=1.2 fm; h=6.63×10^{-34}Js; velocity of light in vacuum, c=3×10^8 m/s