B. Sc. Physics (Hons.) Examination, 2025

(3rd Year, 1st Semester)

PHYSICS

Paper : DSE/TH/02-A1

(Nuclear and Particle Physics)

Time : *Three Hours* *Full Marks* : 75

[CO1] : Answer *any* **one** question : 10×1=10

1. *(a)* What do you mean by nuclear spin? Why is it not very large for a big nucleus having large number of nucleons?

(b) Discuss about the different properties of nuclear force. Draw a realistic graph to show the variation of nuclear force with distance and explain its different parts.

(c) The binding energy per nucleon for ^{235}U is 7·6 MeV. The nucleus undergoes fission to produce two fragments, both having binding energy per nucleon 8·5 MeV. Find the energy released from complete fission of 1 kg of ^{235}U. (1+2)+(3+2)+2=10

2. Write down the disintegration equations for the three types of beta decay processes. Which process is energetically least probable? Justify your answer. Predict the properties (charge, spin and mass) of neutrino from the observed facts. Neutrino energy spectrums for beta minus decay and electron capture process are not similar — why? 3+3+2+2=10

[CO2] : Answer *any* **one** question 10×1=10

3. *(a)* What is radiative capture? Give one example.

(b) How fixed target nuclear reactions can be classified depending on the energy of the projectile nucleus? Discuss about the angular distribution of ejected particles in each case.

(c) What are endoergic reactions? How they are energetically possible? 2+(2+2)+(2+2)=10

4. *(a)* What do you mean by nuclear reaction cross-section? What is its geometrical significance?

(b) State and explain Bohr's theory of compound nuclear reactions. Write down the expression for compound nuclear reaction cross-section and explain each term. Do you think that same compound nucleus can decay in different channels? Justify your answer.
(2+1)+(3+2+2)=10

[CO3] : Answer *any* **two** questions : 10×2=20

5. A proton and a deuteron lose same amount of energy in passing through a thin sheet of lead. What is the ratio of their energies? Which formula have you used to solve the problem? Deduce it in terms of maximum and minimum impact parameter. What do you mean by breakdown region of this formula?
3+5+2=10

6. *(a)* What are the main interactions by which a beta particle loses energy in a medium? Discuss about their relative importance and graphically show how it changes with beta energy. Among them which interaction is not considered for alpha particles moving through a material and why?

13. *(a)* What are the basic forces in nature? Discuss how the forces can be explained in terms of exchange mechanism and name the exchange particles for different basic forces. How will you get an idea about the range of the force from this concept?

(b) What is color charge? How the particles having color charge interact? (2+3+3)+2=10

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(b) How a semiconductor diode can be used to detect a charge particle? Discuss with diagram. What are the advantages of semiconductor detector over gaseous detectors? (1+2+2)+(4+1)=10

7. Draw a diagram to show how gas filled detector behaves with the increase of applied voltage for two beta particles of different energy. Is there any difference between the two curves? Justify your answer. Mention the names of different gaseous detectors and specify their region of operation in the diagram. How multiple count for a same particle can be avoided in the highest voltage operating region of the gas filled detector? 5+2½+2½=10

[CO4] : Answer *any* **two** questions : 7½×2=15

8. *(a)* Which effect shows that Cosmic rays are mainly charged particles? Explain the effect.

(b) What do you mean by primary and secondary Cosmic rays and what are their constituents? How the major constituents of the secondary Cosmic rays are formed (give necessary equations)? 2½+(3+2)=7½

9. Why Cyclotrons are not suitable for accelerating electrons to relativistic speed? Which type of accelerator is suitable for this and which principle is used for acceleration in such an accelerator? Show that spatially varying magnetic field is required for this and find the condition which should be maintained for the magnetic field. Why pulsed beam is obtained in this accelerator? 1+1½+3+2=7½

10. *(a)* Show that the total length of the drift tubes in a LINAC having n drift tubes is given by

$$L = (1/2f)(2qV_{max}/m)^{1/2}\sum_1^n \sqrt{n}$$

Symbols have their usual meanings.

(b) What will be the final energy (in MeV) of a hydrogen nucleus accelerated in a cyclotron of radius 0·4 m by an alternating potential of maximum value 50 kV whose polarity is reversed 3×10^7 times a second? Also find the number of revolution of the nucleus to achieve this energy. 3½+4=7½

[CO5] : Answer *any* **two** questions : 10×2=20

11. *(a)* What are leptons? Write down the name and symbol of the members of 1st and 2nd generation leptons. Are they stable? Justify your answer.

(b) What are hadrons? What do you mean by strange hadrons and what are their properties?

(c) What is isospin? Explain with example. 5+3+2=10

12. *(a)* What is hypercharge (Y) quantum number? In which interaction(s) it is conserved? How it is related to the charge of the particle?

(b) Determine the values of quantum number Y and I_3 for nine pseudoscalar mesons (spin parity = 0^-) and plot them in weight diagram.

(c) Write down the quark contents of any two members of the above mentioned meson octet. 3+5+2=10