B.Sc. 5th Semester (Honours) Examination, 2020-21

PHYSICS

Course ID: 52417 **Course Code: SH/PHS/504/DSE-2**

Course Title: Nuclear and Particle Physics

Time: 2 hours **Full Marks: 40**

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Section-I

1. Answer *any **five*** of the following questions: 2×5=10

a) What is nuclear magneton? Calculate the ratio between nuclear magneton and Bohr magneton.

b) Why electrons cannot be accelerated in a cyclotron?

c) What is Cherenkov radiation?

d) Why pair production is not possible in vacuum?

e) What are the prompt and delayed neutrons?

f) Which conservation laws are violated in the nuclear reaction $p \rightarrow \pi^+ + e^+ + e^-$?

g) Discuss the effects of galactic magnetic field on incoming cosmic rays.

h) What is the importance of photomultiplier tube in a scintillation detector?

Section-II

2. Answer any ***four*** of the following questions: 5×4=20

a) Distinguish between the 'fundamental interactions' mentioning the 'exchange particles' in each case. Calculate the mass of the exchange particle in case of strong interaction (e.g nucleon-nucleon interaction), if the range of interaction is 0.5 Fermi (Assuming the speed of exchange particle is equal to velocity of light). 3+2 = 5

b) Discuss the "Saturation property of nuclear force"? How does the binding energy vary with the mass number of nuclei? What is the origin of magnetic moment of neutron? Why the electric dipole moment of nucleus does not exist? 2+1+1+1=5

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c) What is reaction cross section? A 0.01mm thick ${}^{7}_{3}Li$ plate is bombarded with a beam of intensity 10^{13} protons per second. As a result 10^{8} neutrons are produced. Determine the reaction cross-section if the density of *Li* is 500 kg/m^3. 1+4=5

d) Discuss the working principle of Betatron? What is its limitation? What is the difference between Betatron and Cyclotron? 3+1+1 =5

e) What is 'Spallation' related to nuclear reactions?
Which of the following reactions can occur? State the conservation laws violated or followed in each case.

i) $\pi^0 \rightarrow \gamma + \gamma$

ii) $K^- + p \rightarrow \Lambda^0 + \pi^+ + \pi^-$

iii) $e^+ + e^+ \rightarrow \mu^+ + \pi^-$ 2+3 = 5

f) Mention the different modes of nuclear β-decay with their representative equations. In the decay $\Sigma^0 \rightarrow \Lambda^0 + \gamma$, the half-life of Σ^0 is 10^{-12} s. Discuss the nature of the interaction of this decay. 2+1+2=5

Section-III

3. Answer any ***one*** of the following questions: 10×1=10

a) (i) Derive the expression for Q value of a nuclear reaction. The Q value of the reaction ^{23}Na(n, α)^{20}F is -5.4 MeV. Determine the threshold energy of the neutrons for this reaction.

(ii) What are the evidences that a nucleus can be assumed as a liquid drop? What are the evidences that a nucleus can have shell structure? Write down the limitations of liquid drop model and shell model picture of nucleus.

(3+1)+(2+2+2) = 10

b) (i) Draw the voltage characteristics curve of GM counter explain each region.

(ii) Can a proton decay into neutron? Explain.

(iii) Which of the following isobars would you expect to be β^- active? How would it decay and why?

$Ni_{28}^{64} = 63.9280u, Cu_{29}^{64} = 63.9298u$

(iv) Write down the quark compositions of antiproton and antineutron.

(v) What kind of neutron is needed for nuclear fission? Does nuclear fission occur with fast neutron? Explain.

3+2+2+1+2 = 10