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Total No. of Questions: [11]

M.Sc. (Physics) (Semester – 4th)
PARTICLE PHYSICS
Subject Code: MPHYS1419
Paper ID: [18220716]

Time: 03 Hours **Maximum Marks: 60**

Instruction for candidates:

1. Section A is compulsory. It carries 16 marks. It consists of 4 questions of 4 marks each.
2. Section B consist of 4 questions of 8 marks each. The student has to attempt any 3 questions out of it.
3. Section C consist of 3 questions of 10 marks each. The student has to attempt any 2 questions.

Section – A **(4 marks each)**

Q1. Check whether the following reactions are feasible or not. If feasible, then mention the name of the interaction through which the decay will take place, but if not feasible then demonstrate the conservation law violated.

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

(ii) $e + p \rightarrow \nu_e + \pi^0$

(iii) $p \rightarrow e^+ + \gamma$

(iv) $p + p \rightarrow p + p + p + \bar{p}$

Q2. Discuss the origin of the color quantum number with the help of suitable examples.

Q3. Show that Dirac current satisfies the continuity equation.

Q4. Consider the decay at rest $\tau^- \rightarrow \pi^- + \nu_\tau$, where the spin of tau is in positive Z-direction while neutrino and pion travel in $\pm$Z-directions. Sketch the allowed configurations assuming that the form of weak charged-current interaction is (i) V-A (ii) V+A.

Section – B **(8 marks each)**

Q5. Describe the properties of π-mesons including their decay modes. What are the quark compositions of Σ^+ & Λ^0 baryons?

Q6. Define Parity, charge conjugation and time-reversal. Also state and explain the CPT theorem.

Q7. Show why observation of the process $\bar{\nu}_\mu + e \rightarrow e + \bar{\nu}_\mu$ constitutes unique evidence for neutral currents while the observation $\bar{\nu}_e + e \rightarrow e + \bar{\nu}_e$ does not. Prove that maximum angle of emission of the recoil electron to the neutrino beam direction is $\sqrt{\frac{2m}{E}}$, where m and E are the mass and energy of the electrons, respectively.

Q8. Show that Dirac lagrangian is not invariant under "local gauge transformation" represented as $\psi \rightarrow e^{i\theta(x)}\psi$. Also demonstrate how the introduction of massless gauge field makes this lagrangian invariant. Why the gauge field introduced should be massless?

Section – C **(10 marks each)**

Q9. a. What are "Strange Particles"? How are these classified? Also explain the strangeness quantum number with the help of examples. (6)

b. What is the typical value of the average life time of strange particles? Briefly explain the reason for having life time of this order. (2)

c. A Ξ^0 particle finally decays into non-strange particles. Write the decay sequence for this reaction. (2)

Q10. a. Construct the baryon octet for SU(3) symmetry. (8)

b. Describe briefly the origin of isospin asymmetry. (2)

Q11. a. Write a short note on the "Cabibo Theory". (5)

b. If one compares the decay of Kaons into $\mu + \nu_\mu$ with another feasible decay $e + \nu_e$, the value of ratio of decay widths $\left(\frac{\Gamma(K\rightarrow\mu+\nu_\mu)}{\Gamma(K\rightarrow e+\nu_e)}\right)$ is $\sim 10^4$. Explain this observation on the basis of the fermi theory of β −decay. (5)