2023
M.Sc.
4th Semester Examination
PHYSICS
PAPER – PHS-401
Full Marks: 50
Time: 2 Hours
Paper code: 401.1(Particle Physics)

Answer any Two (02) of the following: 2×2=4

1. (a) What do you mean by "exchange and internal symmetries" of the particles?

(b) Which of the following reactions are allowed?

(i) $n \rightarrow p + e^- + \bar{\upsilon}_e$ $(ii) p \rightarrow e^+ + \gamma$

(c) Write down the hexagons of the baryon decupletalong with their quark content.

(d) What do you mean by "homomorphism and isomorphism"?

Answer any Two (02) of the following: 2×4=8

2. State which of the following processes are allowed and which are forbidden, giving reasons in terms of conservation laws and stating the dominant interaction in the case of allowed processes:
(i)$e^- + p \rightarrow \nu_e + n$ (ii) $\pi^- + p \rightarrow \Sigma^+ + K^-$ [4]

3. Write down the baryon and meson octets and gives the physical explanations of above two. [2+2]

4. (a) Write Young diagrams of irreducible representation of S_4.
(b) Suppose we have a set of transformation $x' = f(x, a)$. Also assume that an identity transformation exists and that the transformations are associative. Write down the requirements to form a Lie group. [2+2]

5. Show that SU(2) has the same Lie algebra as SO(3). [4]

(Turn Over)

Answer any One (01) of the following: **1× 8=8**

6. (a) Calculate the generators of the SO(3) group.
   (b) Discuss CPT theorem.
   (c) Find the basis functions of S_3. [4+2+2]

7. (a) Define Mandelstam variables in $2 \rightarrow 2$ process and show that $s + t + u = \sum_{t=a}^{d} m_i^2 = constant.$ (b) What is hypercharge? How it is connected with the multiplate of the group of the respective particle. (c) Explain the formation of proton and anti-proton by charge conjugation. [4+2+2]

Paper code: 401.2 (Statistical Mechanics-II)

Answer any two (02) from the following: **2×2=4**

1. (a) Draw the variation of chemical potential μ with temperature T for the ideal Fermi gas and the ideal Bose gas

   (b) What is the significance of the Fermi-Dirac distribution function in describing the occupation probabilities of energy levels in an ideal Fermi gas?

   (c) What is an order parameter? Explain with an example.

   (d) Discuss the concept of degeneracy and explain how it affects the behaviour of an ideal Fermi gas.

2. **Answer any two (02) from the following:** **2×4=8**

   (a) For a one-dimensional Ising system of N spins in a field h, determine the partition function in terms of eigenvalues of the matrix.

$$\begin{pmatrix} e^{\beta(J+h)} & e^{-\beta J} \\ e^{-\beta} & e^{\beta(J-h)} \end{pmatrix}$$

(Continued)

(b) For particles with spin S, obtain the maximum number of particles per Landau Level.

(c) Explain the concept of Bose-Einstein condensation. Discuss the critical temperature and the condensate fraction in relation to the particle density. 1+3

(d) i) Explain the difference between first-order and second-order phase transitions.

ii) Discuss the concept of universality in phase transitions and its connection to critical exponents. 2+2 = 4

Answer any one (01) from the following: **1×8=8**

3.(a) Show that specific heat of an ideal Bose gas is continuous at the transition point T_c but its derivative is not. (b) Estimate the mean energy of a photon in a black-body radiation cavity at temperature T. 4+4 = 8

4. (a) Show that for a highly degenerate Fermi gas as $T \rightarrow 0$ there exists a limiting valueof susceptibility which is independent of temperature but strongly dependent upon the density of the gas. (b) For an ideal Fermi gas show that the ground state pressure (P_0) of the system varies as $n^{5/3}$ (particle number density). 5+3 = 8

(All the symbols have their usual meanings)

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Internal Assessment-10