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PG CBCS

M.Sc. Semester-IV Examination, 2022

PHYSICS

PAPER: PHS 401

(Particle Physics & Statistical Mechanics-II)

Full Marks: 40 **Time: 2 Hours**

Write the answer for each unit in separate sheet

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

PHS 401.1 Particle Physics

Marks: 20

GROUP-A

1. Answer any two questions: **2×2=4**

a) In Natural unit, Show that 1 Sec = 1.5 x 1024 GeV^{-1}

b) Show that time reversal operator is anti linear.

c) Which interactions are responsible for the below process?

(*i*) $\pi^- + p \rightarrow \kappa^0 + \Sigma^0$

(*ii*) $e^+ + e^- \rightarrow \mu^+ + \mu^-$

d) What is the difference between a pseudoscalar meson and a vector meson?

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GROUP-B

2. Answer any two questions: **2×4=8**

a) Consider the decay of κ^0 meson of momentum p_0 into and of momentum π^+ and $\pi+$ in the opposite direction such that $p_+ = 2p_-$. Find p_0. (m_{κ^0} =498 MeV/C^2, m_{π^+} = 140 MeV/C^2)

b) State and prove CPT theorem.

c) In SU(3) multiplets, prove that $3 \otimes 3 = 6 \oplus \bar{3}$. How many symmetric and antisymmetric states are there?

d) State that $\pi^- + d \rightarrow n + n + \pi^0$ cannot occur for pions at rest.

GROUP-C

3. Answer any one questions: **1×8=8**

a) Construct the famous Gell-Mann Matrices and identify the iso-spin states of each particle in the meson octet.

b) What is τ - Θ puzzle? How it is resolved? Show that $e^+e^- \rightarrow 2\gamma$ is forbidden.

(Turn Over)

PHS 401.2 Statistical Mechanics-II

Marks: 20

GROUP-A

1. Answer any two questions: **2×2=4**

a) Plot the temperature dependence of fugacity for BE and FD statistics.

b) If $E = \frac{3}{2} N k_B T \frac{B_{5/2}(\alpha)}{B_{3/2}(\alpha)}$ *where* $\alpha = -\mu\beta$, show that $C_v \propto T^{3/2}$ in case of BE condensation at $T<T_c$ c) Using $\ln G_z = -\sum \ln\left(1-\eta e^{-\beta E_i}\right)$ Show that the number of particles in the ground state, $N_0 = \frac{\eta}{1-\eta}$ Where η is the fugacity.

d) Consider 4 spin half particle system. How many microstates are possible for total magnetic moment zero?

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GROUP-B

2. Answer any two questions: **2×4=8**

a) For BE condensation, prove that $F = -\frac{2}{3} E$. at $T<T_c$

b) If, $\hat{H} = \frac{p_x^2}{2m} + \frac{1}{2m}\left(p_y + \frac{exH}{c}\right)^2 + \frac{p_z^2}{2m}$ show that $\dot{y}$ is not a constant of motion, although p_y is constant. $\hat{H}$ = magnetic field along z-direction.

c) Find an expression of Fermi energy for 2D metallic system.

d) Prove that free energy of photon gas is $F = -\frac{a}{3} VT^4$, where 'a' is a constant.

GROUP-C

3. Answer any one questions: **1×8=8**

a) In Ising model prove that long range order parameter $L(T) = \tanh \mu_0\beta\left(H + \frac{\gamma J_e L}{\mu_0}\right)$, where $\gamma = n.n$ and other symbols has their usual meaning.

b) Prove that average occupation number $\langle N \rangle = \frac{zV}{\lambda^3} \frac{x}{\sinh(x)}$, in Case of Landau diamagnetism. Where $x = \frac{\beta\hbar eH}{2mc}$, $\lambda = \frac{h}{\sqrt{2\pi m k_B T}}$ and $z = e^{\mu\beta}$.

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