2018

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PGS-401 (Gr. – A + B)

Full Marks : 50

Time : 2 Hours

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.
Answer Q1 and any one from Q2 and Q3 for each of Groups A & B.

(Gr. A – *Particle Physics*)

1. Answer any five bits: 5 X 2 = 10

(i) What is the G-parity operator? Why was it introduced in particle physics?

(ii) "Three charge states of π-meson ($\pi^{\pm,0}$) form an iso-spin triplet in SU(3) symmetry"-Justify the statement.

(iii) Assume the decay $K^0 \rightarrow \pi^+ + \pi^-$ in flight. Calculate the mass of the primary particle if the momenta of each of the secondary particle is 360MeV/c and the angle between the tracks is 70^0.

(iv) What do you mean by resonance particles? Why the known Hadrons are called elementary particles?

(v) Explain the concept of spontaneous symmetry breaking in particle physics.

(vi) Show that Charge Conjugation operator is Hermitian.

(vii) What do you mean by "quark confinement" in Quantum Chromodynamics?

(viii) How many generators are there for SU(2) group? Write down the generators.

(Turn Over)

2. (a) Explain generalized Pauli Principle in the context of a baryon composed of quarks. (2)

(b) Define time reversal operator and hence show that it is anti-unitary. (3)

(c) Show that the rest mass of a photon should be zero but not for π-meson. (2)

(d) Write down the time dependent part of the wave function of a decaying state. Show that the mean life of a proton and anti-proton would be the same. (3)

3. (a) Deduce the following sum rule for pion-nucleon scattering $\sqrt{2}A_0 + A_- = A_+$ where A_+, A_0 and A_- represent the scattering amplitudes corresponding to $\pi^+ p \to \pi^+ p,\ \pi^- p \to \pi^0 n$ and $\pi^- p \to \pi^- p$ processes, respectively. (5)

(b) Check whether the following reactions are possible or forbidden. Comment on their nature, if possible. (i) $\pi^- + p \to \Lambda^0 + \Sigma^+$ (ii) $\pi^- + p \to K^+ + \Sigma^-$ (5)

(Gr. B – *Statistical Mechanics-II*)

1. Answer any five bits: 5 X 2 = 10

(i) What is Bose-Einstein condensation?

(ii) For a quantum Bose gas the grand partition function (Z) can be written as $\ln Z = -\sum_i \ln(1 - e^{\beta(\mu - E_i)})$. Find the mean number of particles N_0 in the ground state.

(iii) In mean field theory of Ising model, magnetization is given by $m = \tanh(qJm + h)\beta$ where h is the applied field. Obtain the graphical solution of this self-consistent equation at T_c, below T_c and above T_c.

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

(v) What is the chemical potential for a gas of photons in thermal equilibrium? Explain with reason.

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(vi) Under what conditions for a gas containing particles, one can apply Boltzmann statistics although the particles obey Fermi or Bose statistics?

(vii) Argue that the specific heat of electrons at low temperature is proportional to temperature.

(viii) The spectral density of black body radiation has a particular form proposed by Wien as $u(\lambda)d\lambda = \frac{f(\lambda T)d\lambda}{\lambda^5}$. Show that there exists a maximum in $u(\lambda)$ corresponding to a wavelength λ_m.

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

$$\begin{pmatrix} e^{\beta(J+h)} & e^{-\beta J} \\ e^{-\beta J} & e^{\beta(J-h)} \end{pmatrix} \quad (5)$$

(b) Show that only large eigenvalue will contribute to the free energy. (3)

(c) Further show that at zero magnetic field the magnetisation is zero for all temperatures. (2)

3. (a) Starting from the following relations for the free Fermi gas $\frac{P}{kT} = \frac{f_{5/2}(z)}{\lambda^3}$ and $\frac{N}{V} = \frac{f_{3/2}(z)}{\lambda^3}$. Show that $S = \frac{U-A}{T} = Nk\{\frac{5}{2}\frac{f_{5/2}(z)}{f_{3/2}(z)} - \ln z\}$ (5)

(b) Obtain the density of states of non-relativistic free electrons in three dimensions. (2)

(c) An idealized White dwarf star at a temperature 10^7 K behaves as an ideal Fermi gas of density of electron 10^{30}/cc. Find the equivalent Fermi temperature of such a system. (3)

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(Internal Assessment – 10)