2019

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PHS-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.
Use separate answer scripts for Group A and Group B.

(Gr. A – *Particle Physics*)
Answer Q1 and any one from Q2 and Q3.

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

(a) Write down CPT theorem and hence show that the total mean lifetime of a particle is equal to that of its anti-particle.

(b) Justify that the existence of electric dipole moment of neutron corresponds to CP violation.

(c) What do you mean by a casimir operator? Write down the significance of this operator.

(d) Calculate the value of the structure constants f_{458} and f_{376} in SU(3).

(e) Explain, in brief, the concept of strangeness and isospin for the elementary particles.

(f) Assuming π meson (m_π = 140 MeV) to be the mediator for strong interactions, estimate the range of strong interactions.

(g) Why was Color quantum number introduced in Quantum Chromodynamics?

(Turn Over)

(h) Write down Gell-Mann-Nishijima formula. Hence, find the third component of isospin of u-type and d-type quarks.

2. (a) Write down the basic postulates of Quark model. Justify that SU(3) flavor symmetry is a broken symmetry. (2+1)

(b) Use the tensor method to calculate 4⊗4⊗4 in SU(4). (3)

(c) What do you mean by Mandelstam variables? Calculate the maximum kinetic energy of the electron emitted in the muon decay at rest $(\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu)$. (1+3)

3. (a) Show that $\sigma_a(p+p \rightarrow d+\pi^+) : \sigma_b(p+n \rightarrow d+\pi^0) : \sigma_c(n+n \rightarrow d+\pi^-) = 2:1:2$ where, d stands for deuteron and notations have their usual meaning. Assume isospin invariance. (4)

(b) Explain why $\omega \rightarrow \pi^0 +$ is allowed, but $\omega \rightarrow \pi^0 + 2\gamma$ is not allowed. (2)

(c) How could the intrinsic parity of a negative pion (π^-) is measured? (4)

(Gr. B – *Statistical Mechanics-II*)
Answer Q1 and any one from Q2 and Q3.

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

(a) For an ideal Bose gas how does condensate fraction (N_0/N) varies with temperature?

(b) For a black body radiation what is the mean value of ε_s?

(c) What are critical exponents and universality classes?

(d) Show that $z\frac{\partial f(z)}{\partial z} = f_{\gamma-1}(z)$, where $f_\gamma(z)$ are Fermi-Dirac functions.

(e) What is order parameter? Explain with example.

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(f) Explain the origin of Landau level degeneracy?

(g) Compute the average energy of 2d free electrons at zero temperature.

(h) Explain physically why the Pauli paramagnetic susceptibility for metal is independent of temperature.

2. Starting from the following relations for the free Bose gas $\frac{P}{kT} = \frac{g_{5/2}(z)}{\lambda^3}$ and $\frac{N-N_0}{V} = \frac{g_{3/2}(z)}{\lambda^3}$, $U = \frac{3}{2}KT\frac{V}{\lambda^3}g_{5/2}(z)$

(a) Calculate specific heat for $T>T_c$ and $T<T_c$. (2+3)

(b) Show that specific heat is continuous at transition point but its derivative is not. (5)

3. (a) Consider a system of non-interacting spin half fermions in the presence of an external magnetic at absolute zero temperature. Calculate the value of low field susceptibility for the system. (4)

(b) Starting from Landau's Phenomenological theory calculate the value of the critical exponents γ and δ. All the symbols have their usual meaning. (3)

(c) Argue that the specific heat of electrons at low temperature is proportional to temperature. Is it valid for two-dimensional electrons too? (2+1)

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(Internal Assessment – 10)