Sec. 2017–18

Total pages: 3

PG (CBCS)
M.Sc. Semester-IV Examination, 2019
PHYSICS
PAPER: PHS-401

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

Use Separate Answer Scripts for each unit

GROUP-A

PARTICLE PHYSICS

Marks-20

Answer question number 1 and any one from the rest.

1. **Answer any five questions** **5×2=10**

a) Classify the following reactions:

i) $\pi^0 \rightarrow p + \pi^-$

ii) $K^0 \rightarrow \pi^+ + \pi^-$

b) Explain spontaneous symmetry breaking in particle Physics.

c) What is G-parity? Where is it conserved?

d) $p^+ + \pi^- \rightarrow n^0 + \gamma + Q$

[Mass in MeV: $\pi^-(139)$, $p^+(938)$, $n^0(939)$]

Calculate the energy of the neutron produced.

e) If a Higg's boson of mass m_H moving with a speed $\beta = v/c$ decays into a pair of photons, then find the invariant mass of the photon pair.

f) Find the dimension of adjoint representation of SU(N).

g) Show that s+t+u=$\sum_i m_i^2$ where the symbols have usual meaning.

h) $P A^0 P^{-1}$ = ……

$P \vec{A}(x) P^{-1}$ = ……

If $\mathcal{L}_{int}$ = - $h\bar{\psi}\gamma_5\psi\phi$, what is the dimension of h?

2. a) Show that $|K_0\rangle$ and $|\overline{K_0}\rangle$ are not eigen states of the operator CP. Construct eigen states of CP operation from linear superposition of $|K_0\rangle$ and $|\overline{K_0}\rangle$. Find the eigen values also. (5)

b) Discuss how the intrinsic parity of π^- can be determined from the reaction $\pi^- d \longrightarrow n + n$ (5)

3. a) Prove that the quark model predicts the following cross-section relation $\sigma(\Sigma^- n) = \sigma(pp) + \sigma(k^- n) - \sigma(\pi^- p)$ (4)

b) Using Young Tableaux method for SU(3) group show that $3 \otimes 3 \otimes 3 = 10 \oplus 8 \oplus \bar{8} \oplus 1$ (4)

c) What is self energy? Explain with Feynman diagram. (2)

(Turn Over)

GROUP-B

STATISTICAL MECHANICS-II

Marks-20

Answer question number 1 and any one from the rest.

1. **Answer any five questions** **$5\times 2 = 10$**
   a) How is the paramagnetism of conduction electrons different from metallic paramagnetism?
   b) How does Landau level leads to the quantization of energy?
   c) Consider N independent spin ½ particles in an external magnetic field. Each spin has a magnetic moment μ. What is the magnetisation of the spins as a function of the external magnetic field and temperature?
   d) The Bose-Einstein condensation temperature for a Rubidium gas (atomic weight 85.47) is 1.7×10^{-23}K. Calculate the number density of the condensate (N_A=6.023×10^{23}, k_B=1.381×10^{-23} J/K).
   e) What do you mean by degenerate Fermi gas?
   f) Explain qualitatively the idea of Yang-Lee singularity for 1D Ising system.
   g) Using ln Z_G = - $\sum_r \ln(1-\eta e^{-\beta\epsilon_i})$, show that the number of particle in the ground state is N_0=$\frac{\eta}{1-\eta}$, where η is the fugacity.
   h) Explain why liquid helium does not solidify in normal atmospheric pressure.

2. a) Consider an ideal Fermi gas of N particles in a volume V and in a magnetic field H at temperature T=0. The energy of a particle is $\epsilon = \frac{p^2}{2m} \pm \mu_B H$, where μ_B is Bohr magneton. Give an expression for the chemical potential μ_0 in terms of the number of particles N for vanishing magnetic field.
   Write down the Fermi momenta of the spins oriented parallel and anti-parallel respectively to the external magnetic field H≠0, Find the total energy of the spins oriented parallel and anti-parallel to the external magnetic field. (4+2+2)
   b) What is De Hass-van Alphan effect? What is the significance of this? (2)

3.
   $H = - J\sum_{i=0}^{N}\sigma_i\,\sigma_{i+1} - h\sum_{i=0}^{N}\sigma_i$
   i) Find the partition function in the N→∝ limit.

(Turn Over)

ii) Hence show that the magnetisation of the system is

$$M = N\frac{\sinh \beta h}{\sqrt{\exp(-4\beta h)+sinh^2(\beta h)}}$$

Also show that this model, in one dimension, does not exhibit any phase transition at finite temperature (T>0). (2+4)

b) Obtain an expression for the mean energy $\bar{E}$ of the Ising model in 2D when the applied field is zero, using the simplest mean field approximation. Hence show that the heat capacity C_h has the behaviour:

$C_h = 0$ for $T>T_C$

$= 3Nk/2$, for $T < T_C$

Comment on the nature of singularity at T_C. (4)

******