2019

PG

4th Semester Examination

PHYSICS

Paper - PHS 401

Full Marks : 20 Time : 2 Hours

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

Group - A

(Particle Physics)

Answer Q. No. 1 and any *one* from the rest.

1. Answer any *five* bits : 2×5=10

(a) Show that (i) $\rho \rightarrow \eta + \pi$ is forbidden as a decay through strong interaction.

(ii) $\omega \rightarrow \eta + \pi$ is forbidden as an eletromagnetic or strong decay.

[Turn Over]

(b) $PA^0(x)P^{-1} = ...$

$P\bar{A}(x)P^{-1} = ...$

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

(c) $H \to Z^0 + \gamma$ If the rest masses of the Higgs (H) and Z^0 boson are $125\,Gev/c^2$ and $90\,Gev/c^2$ respectively, and the decaying Higgs particle is at rest, find the energy of the photon.

(d) Prove that $\bar{\psi}\gamma^5\psi$ is psendo-scalar under parity transformation.

(e) Find the dimension of adjoint representation of *SU(N)*.

(f) $\pi^- + p^+ \to n^0 + \gamma + \phi$

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

Calculate the energy of the neutron produced.

(g) Draw the Feynman diagram for the decay $\wedge^0 \to p + \pi^-$ [$\wedge^0 = uds$]

(h) In which isospin states can

(i) $\pi^+\pi^-\pi^0$

(ii) $\pi^0\pi^0\pi^0$ exist ?

2. (a) Show that $|K_0\rangle$ and $|\bar{K}_0\rangle$ are not eigen states of the operator CP. Construct eigen states of CP operation from linear superposition of $|K_0\rangle$ and $|\bar{K}_0\rangle$. Find the eigenvalues also.

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

(c) What is Self-energy? Explain with Feynman diagram.

3. (a) Analyze the pion-nucleon scattering data in terms of isospin amplitudes $a_{1/2}$ and $a_{3/2}$ for the reactions : $\pi^+ + p \to \pi^+ + p$

$$\pi^- + p \to \pi^- + p$$

$$\pi^- + p \to \pi^0 + n$$

Prove that $\sqrt{\sigma^+} + \sqrt{\sigma^-} - \sqrt{2\sigma^0} \geq 0$

[Turn Over]

(b) Explain why at the same energy the total cross-sections $\sigma(\pi^- + p) \cong \sigma(\pi^+ + n)$

while $\sigma(\kappa^- + p) \neq \sigma(\kappa^+ + n)$.

How can the neutral K-mesons, K^0 and $\overline{K}^0$ be distinguished?

Group - B

(Statistical Mechanics - II)

Answer Q. No. 1 and any *one* from the rest.

1. Answer any *five* bits : $2\times5=10$

(a) Using $\ln Z_G = -\sum \ln\left(1-\eta e^{-\beta\varepsilon_i}\right)$ show that the number of particles in the ground state

$N_0 = \dfrac{\eta}{1-\eta}$ where η is the fugacity.

(b) Show that for a free electron gas at zero degree Kelvin, the de Broglic wavelength

$$\lambda_F = 2\left(\frac{\lambda}{3n_0}\right)^{\frac{1}{3}}$$

(c) Consider a system of 4 spin-$\frac{1}{2}$ system. How many microstates are possible for total magnetic moment zero.

(d) In two dimensions, what fraction of fermi-energy gives rise to the average energy per electron at $T = 0$.

(e) Show that the specific heat at constant volume of an ideal gas in the condensed phase ($T < T_0$) varies as $T^{3/2}$.

(f) For one dimensional Ising system, Hamiltonian

$$H = -J_1 \sum_{i=1}^{N-1} S_i S_{i+1} - J_2 \sum_{i=1}^{N-2} S_i S_{i+2}$$

Find the transfer matrix.

(g) In Bethe Pearl's approximation for Ising system,

$$H = -h \sum_{i \to 0}^{N} S_i - J \sum_{i=1}^{N} S_i S_o$$

Write down the expression of canonical partition function.

[Turn Over]

(h) State briefly, how can you identify the condensate experimentally.

2. (a) For ideal Bose gas

Prove that $\frac{P}{K_B T} = \frac{1}{\lambda^3} \sum_{l=1}^{\infty} \frac{\mu^l}{l^{5/2}}$

and $\frac{N - N_0}{V} = \frac{1}{\lambda^3} \sum_{l=1}^{\infty} \frac{\mu^l}{l^{3/2}}$

where the symbols have their usual meanings.

3+2

(b) In Ising system (one dimensional) Hamiltonian

$$H = -J \sum_{i=1}^{N} \sigma_i \sigma_{i+1} - h \sum_{i=1}^{N} \sigma_i$$

(i) Find the partition function in the limit $N \to \infty$.

(ii) Show that magnetization of the system

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

2+3

3. (a) Obtain the molar energy of Fermions as function of the temperature in the lowest order of temperature. 5

(b) In Ising model $H = -\sum_{i=1}^{N} J_i S_i S_{i+1}$

Calculate the correlation function $\langle S_i S_{i+r} \rangle$. 5