2018

M.Sc. 4th Semester Examination

PHYSICS

PAPER—PHS-401

Subject Code—33

Full Marks : 40

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.

Illustrate the answers wherever necessary.

Use separate Answer-scripts for Group-A & Group-B

Group-A

[Marks : 20]

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

1. Answer any *five* bits : 5×2

(a) How many components are there is $\bar{\psi}\gamma^5\gamma^\mu\psi$ and $\bar{\psi}\gamma^5\psi$?

(b) In SU(3) multiplets prove that

$$3 \otimes 3 = 6 \oplus \overline{3}$$

How many symmetric and antisymmetric states are there ?

(c) Use isospin invariance to show that the reaction cross-section σ must satisfy

$$\frac{\sigma\left(pp \rightarrow \pi^{+} d\right)}{\sigma(np \rightarrow \pi^{\circ} d)} = 2$$

given that the deuteron d has isospin I = 0 and the π has isospin I = 1.

(d) A pion at rest deceys into a muon and a neutrino. If life time of muon is τ, how far will the muon will travel (in vacuum) before disintegrating ?

(e) (i) $\Sigma^{\circ} \rightarrow \wedge^{\circ} + \gamma$

(ii) $e^{+} + e^{-} \rightarrow \mu^{+} + \mu^{-}$

(iii) $\pi^- + p \rightarrow k^\circ + \Sigma^\circ$

(iv) $\pi^- \rightarrow \mu^- + \overline{\nu_\mu}$

Classify the interactions of the above reactions.

(f) $A + A \rightarrow A + A$

If $\vec{p}$ is the C.M. momentum of the, incident perticle and θ is the scattering angle prove that Mandelstam variables

$$t = -2p^2(1-\cos\theta)/c^2$$

$$u = 2p^2(1+\cos\theta)/c^2.$$

(g) Draw Meson octet model.

(h) $$V(\phi) = \frac{1}{2}\mu^2\phi^2 + \frac{1}{4}\lambda\phi^4 \quad (\lambda > 0)$$

Sketch $V(\phi)$ vs ϕ for +ve and –ve μ^2, when symmetry is broken ?

(Turn Over)

2. (a) State and prove CPT theorem.

(b) Explain how the parity of k^- meson has been determined experimentally ?

(c) A π° meson at rest decays into two photons of equal energy. What is the wave length (in n.m) of the photons ?

$\left(m_{\pi^\circ} = 135 \text{ Mev} / c^2\right)$ 4+4+2

3. (a) Two particles X and Y can be produced by strong interaction

$$k^- + p \rightarrow k^+ + X$$

$$k^- + p \rightarrow \pi^\circ + Y$$

Identify the particles X (1, 321 Mev) and Y (1, 192 Mev) and deduce their quark content. If their decay schemes are $X \rightarrow \wedge + \pi^-$ and $Y \rightarrow \wedge + \gamma$ give a rough estimate of their life lime.

(b) Calculate the branching ratio for the decay of the resonance Δ^+ (1232) which has two eecay modes.

$$\Delta^+ \rightarrow p\pi^\circ$$
$$\rightarrow n\pi^+$$

(c) In which isospin states can (i) $\pi^+\pi^-\pi^\circ$ (ii) $\pi^\circ\pi^\circ\pi^\circ$ exist ?

4+4+2

Group-B

[Marks : 20]

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

1. Answer any *five* bits : 2×5

(a) Write down the equation of state for BE/FD gas.

(b) Consider a system of particles in two dimension with momentum $\vec{p}$ and energy $E = c|\vec{p}|$, c being a constant. The system is maintained at inverse temperature β, volume V and chemical potential μ. What is the grand partition function of the system ?

(c) Prove that compressibility of Bosonic atoms at temperature T is

$$\frac{1}{k_B T n}\left(\frac{1}{1-\frac{\lambda^3 n}{2^{3/2}}}\right)$$

where n is the atomic density and λ is the average thermal de-Broglie wavelength.

(d) Prove that Dirac flux quantum is $\left(\frac{hc}{e}\right)$.

(e) Prove that for non-degenerate Fermi gas

$E_f = k_B T \ln\left(\frac{n\lambda^3}{2}\right)$ in 3D.

(f) What is Rushbrooke inequality ?

(g) Plot magnalization $M(T, H)$ vs T for $H > 0$, $H < 0$, $H \to 0$ at $T < T_c$.

(h) Plot field-free specific heat of an Ising lattice in Bethe pearl and Bragg-William approximation in 2D with mathematical expression.

2. (a) For a zero-dimensional quantum system consisting of a single two-state object whose Hamiltonian can be expressed as

$$H = \begin{pmatrix} \varepsilon & -\Delta \\ -\Delta & -\varepsilon \end{pmatrix}$$

Prove that partion function can be expressed in terms of the partition function of an Ising model in one-dimensional chain of N sites. Also prove that ordering field

$$h = \frac{1}{2} \ln\left(\frac{N - \beta\varepsilon}{N + \beta\varepsilon}\right).$$

(b) Find an expression of cut-off frequency of n-dimensional solid in Debye model. (3+2)+5

3. (a) Find an expression of density of states for n-dimensional free electron gas.

(b) Prove that average energy per photon at 10^3k is 0.56 eV.

(c) A lattice of (N + 1) sites has spins $S_i = \pm 1$ at each site, all of which are acted on by a magnetic field.

$$H = -h \sum_{i=0}^{N} S_i - J_e \sum_{i=1}^{N} S_i S_0 .$$

Calculate $\langle S_i \rangle$ and $\langle S_0 S_i \rangle$. (3+2)+(2+3)