2016

M.Sc.

3rd Semester Examination

PHYSICS

PAPER—PHS-303

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

(*Nuclear Physics-I*)

[Marks : 20]

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

1. Answer any *five* bits : 2×5

(a) Photons of energy 0.3 eV, 3 eV, 3 KeV and 3 MeV strike the matter. What interactions would you expect to be important ?

(b) Calculate the energy to be imparted to an α-particle to force it into the nucleus of $_{92}U^{238}$ (r_0 = 1.2 fm).

(c) Classify the following transitions (the spin parity, J^P, of the nuclear states are given in brackets) :

$$^{14}O \rightarrow {}^{14}N^* + e^+ + \nu \ (0^+ \rightarrow 0^+)$$
$$^{17}F \rightarrow {}^{17}O + e^- + \nu \ (^5/_2{}^+ \rightarrow {}^5/_2{}^+)$$

(d) Show that the electric quadrupole moment of a nucleus vanishes for Nuclear spin I = 0 or I = $\frac{1}{2}$.

(e) Estimate the ratios of the major to minor ones of $^{123}_{51}Sb$. The quadrupole moment is -1.2×10^{-24} cm^2.

(f) A $D_{5/2}$ term in the optical spectrum of $_{19}K^{39}$ has a hyperfine structure with four components. Find the spin of the nucleus. What interval ratios in the hyperfine quadruplet are expected ?

(g) What is Cerenkov radiation ? What are the causes of it ?

(h) Examine the possibilities of isomeric transition between nuclei ^7_4Be and ^7_3Li.

2. (a) $_{36}Kr^{88}$ decays to $_{37}Rb^{88}$ with the emission of β-rays with a maximum energy of 2.4 MeV. The trac of a particular electron from the nucleur process has a

curvature in a field of 10^3 gauss of 6.1 cm. Find :

(i) The energy of this electron in eV and that of the associated neutrino.

(ii) The maximum possible K.E. of the recoiling nucleus. 3+3

(b) Show that in β-ray spectrum the most intense energy occurs at $E = \frac{E_{max}}{5}$. 4

3. (a) Show that electron-positron pair cannot be created by an isolated photon. 3

(b) What do you mean by double focussing mass spectrometer? Draw the block diagram of it. 3

(c) What are the expected types of gamma ray transitions between the following states of odd A nuclei :

(i) $g_{9/2} \rightarrow p_{1/2}$

(ii) $f_{5/2} \rightarrow p_{3/2}$

(iii) $h_{11/2} \rightarrow d_{5/2}$

(iv) $h_{11/2} \rightarrow d_{3/2}$ 4

Group-B

(*Particle Physics–I*)

[Marks : 20]

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

1. Answer any *five* bits : 2×5

(a) $\pi^{\pm} \rightarrow \mu^{\pm} + \nu$

$\pi^{0} \rightarrow 2\nu$

Explain the follow statements. The mean life time of the $\pi^{\pm}$ meson is 2.6×10^{-8}s while that for π° is 0.8×10^{-16}s.

(b) The V-A theory gives the formula for the width (Γ_{μ}) of the muon decay in N.U

$$\Gamma_{\mu} = \frac{\hbar}{\tau} = \frac{G_F^2 m_{\mu}^5}{192\pi^3}$$

$m_{\mu}c^2 = 105.659$ MeV, $\left(G_F/\hbar c\right)^3 = 1.116 \times 10^{-5}$ GeV^{-2}

Calculate the mean life time of muon.

(c) Conventionally nucleon is given positive parity. What does one say about deuteron's parity and the intrinsic parities of u and d-quarks ?

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

(e) Draw the Feynman diagram for

$$\nu_\mu + e^- \rightarrow \nu_\mu + e^-$$

$$\tau^+ \rightarrow \mu^+ + \nu_\mu + \overline{\nu_\tau}$$

(f) Show that $\overline{\psi}\nu^5\psi$ is pseudoscalar.

(g) Show that In SU(3) $\bar{3} \otimes 3 = 8 \oplus 1$.

(h) $|q'\rangle = U(\theta)\,|q\rangle$ where $q = \begin{pmatrix} u \\ d \\ s \end{pmatrix}$.

Write down the expression of $U(\theta)$ in terms of generators of SU(3).

2. (a) Consider the following ratios of the partial decay widths

$$R_1 = \frac{\Gamma\left(\rho^+ \rightarrow \pi^+ + \pi^\circ\right)}{\Gamma\left(\rho^- \rightarrow \pi^- + \pi^\circ\right)} \text{ and } R_2 = \frac{\Gamma\left(\Delta^{++} \rightarrow \pi^+ + \rho\right)}{\Gamma\left(\Delta^- \rightarrow \pi^- + n\right)}.$$ If the effects of e.m. and weak interactions are neglected. Find the ratio of R_1 and R_2.

[I for ρ is 1] 4

(b) Calculate the ratio of the cross sections for the reaction $\pi^-p \rightarrow \pi^-p$ and $\pi^-p \rightarrow \pi^\circ n$ on the assumption that the two I spin amplitudes are equal in magnitude but differ in phase by 30°. 6

3. (a) The coulomb self-energy of a hadron with charge +e or −e is about 1 MeV. The quark content and rest energies (in MeV) of some hadrons are

n(udd)940, p(uud)938, Σ^-(dds)1197, Σ°(uds)1192, Σ^+(uus)1189, $K^\circ(d\bar{s})498$, $K^+(u\bar{s})494$.

The u and d quarks make different contribution to the rest energy. Estimate this difference.

(b) For $\pi^\circ = u\bar{u}$

Prove that $J^{\hat{P}\hat{C}}_{\pi^\circ} = \overline{O}^+$.

(c) Calculate the threshold K.E. of the proton in the Lab. to create an antiproton in a p–p collision.

3+3+4