2015

M.Sc. Part-II Examination

PHYSICS

PAPER—IX

Full Marks : 75

Time : 3 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.

Illustrate the answers wherever necessary.

Use separate answer-scripts for Group-A and Group-B

Group–A

(Nuclear Physics)

[Marks : 40]

1. Answer any *six* of the following : 6×2

(a) What is Fermi-Kurie plot ?

(b) "Nuclei for which β^{+}-decay is energetilally possible may also undergo electron capture, but the reverse is not true" — justify.

(c) Can a nucleus undergo $O^+ \rightarrow O^+$ electromagnetic transition ? If yes, state how ?

(d) A nuclear state is measured to have negative electric quadrupole moment. Comment on the $|\psi|^2$ distribution of this state.

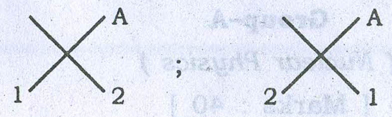
(e) What are the Fertiles and Fessile materials, correlate these with reaction.

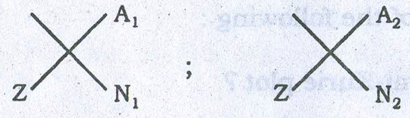
(f) Graphically represent the type of neutrons with energy.

(g) What are the angular moments and parities of the following nuclei :

$${}_7N^{15} \text{ and } {}_{13}Al^{27}$$

(h) Give examples of the following nuclei :

(i) 

(ii) 

(i) Draw the schematic diagram of a mass spectrograph clearly indicating all essential parts.

2. Answer any *two* of the following : 2×4

(a) Why do you get a continuous energy spectrum of the electrons in nuclear beta decay ?

(b) What is mass spectrometer ? What do you mean by double focussing mass spectrometer ?

(c) How would you determine the radius of nucleus by mirror nuclei method ?

(d) Prove that the contribution of coulomb energy in the semi-empirical mass formula of a nucleus of mass number A and atomic number Z is in the form

$$\frac{a\,Z(Z-1)}{A^{1/3}},$$

where a = constant.

3. Answer any *two* of the following : 2×10

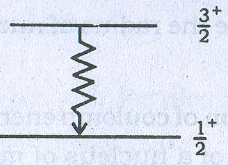
(a) Following Fermi's Theory of beta-decay find out the probability per unit time for the emission of β^- particles in the momentum range p_e and $p_e + dp_e$. From the kurie plot how you conclude about the mass of neutrino ? 10

(b) (i) Chlorine-33 decays by positron emission with a maximum energy of 4.3 Mev. Calculate the radius of the nucleus from this. 5

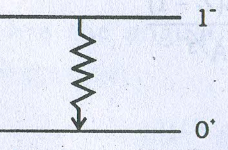
(ii) For what elements should stable isobers exist for (a) A = 97 (b) A = 80 ? 5

(c) What do you mean by multiple channel of γ-radiation? Find the multiple channel of γ-radiations evolved in the following transition with spin, parity values as shown below :

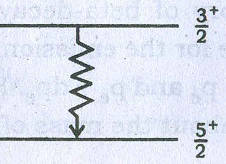
(i)



(ii)



(iii)



(iv) Five groups of α-particles are emitted when $_{83}Bi^{212}$ decays. Their energies are 6.08, 6.04, 5.76, 5.62 and 5.60 Mev. Calculate the α-disintegration energies. 6+4

(d) (i) Deduce Breit-Weigner resonance formula for nuclear reaction.

(ii) Calculate the threshold energy for the nuclear reaction $^{14}N\ (n, \alpha)\ ^{11}B$ in Mev.

(Mass of
^{14}N = 14.0031 u ; ^{11}B = 4.0038 u ;
^{1}H = 1.0078 u ; ^{1}n = 1.0089 u) 6+4

Group–B

[Marks : 35]

Answer Q. No. *1* and *two* from the rest.

1. Justify any five of the following statements with derivation and reasoning wherever possible : 5×3

(a) The threshold kinetic energy for production of an anti-proton in a proton-proton collision in the laboratory is six times the rest mass of the proton.

(b) The isospin symmetry in the strong interaction predicts that the proton and the neutron have same mass.

(c) The tan-theta puzzle has been resolved by proposing that parity is violated in the weak interaction.

(d) The behaviour of the strange particles can be understood on the basis of the strangeness scheme proposed by Gell-Mann Nishijima and Nakono.

(e) The Hamilton's principle leads to the Euler-Lagrange equation for a scalar field (ϕ) system given by the Lagrangian density $\zeta(\phi, \partial_\mu \phi)$.

(f) In natural units the coupling constant e appearing in the interaction Lagrangian density $\zeta = -e\bar{\psi}\gamma^u \psi A_\mu$ is a dimensionless quantity where ψ refers to charged Dirac field and A refers to the electromagnetic field.

(h) The number operator for the Dirac field can have eigenvalues 0 and 1.

2. (a) Assuming the principle of charge independence in the pion-nucleon interaction show that near Δ^{++} (1232) resonance $\sigma(\pi^+ p \to \pi^+ p) : \sigma(\pi^- p \to \pi^- p) : \sigma(\pi^- p \to \pi^\circ n) = 9 : 1 : 2$ where σ denotes the total cross section for the process in the parenthesis. 7

(b) Explain how charge independence in the interaction of the proton and the neutron can be understood on the basis on an Su(2) group and show that the group has three generators. 3

3. (a) Obtain the field equation from the Dirac Lagrangian density

$$\zeta = \bar{\psi}\left[i\gamma^u \partial\mu - m\right]\psi$$ 2

(b) Show that the invariance of the Lagrangian under space-time translation leads to conserved energy-momentum tensor $T^\mu_\nu = \frac{\partial \zeta}{\partial(\partial_\mu \psi)} - \zeta \partial^\mu_\nu$. 6

(c) Show that the Dirac Lagrangian is invariant under a global gauge transformation and interpret the conserved charge. 2

4. (a) Indicate the gauge symmetries involved in the Glashow. Salam-Weinberg model which unifies the electromagnetic and weak interactions and state how the quark, lepton and scalar fields transform under the gauge groups responsible for these symmetries. How many gauge bosons arise in the model ? 6

(b) Explain spontaneous symmetry breaking mechanism in the model yielding a Higgs scalar boson. Is the particle discovered. 2+1

(c) Draw Feynman diagrams for the process $\nu_e + e^- \to \nu_e + e^-$ based on the model. 1

5. (a) $\pi^- + p \rightarrow K^\circ + \Sigma^\circ$

$\pi^- + p \rightarrow K^+ + \Sigma^-$

$\pi^+ + p \rightarrow K^+ + \Sigma^+$

Find the ratio of cross-section for the above reactions assuming C.M energy is such that the channel $I = \frac{3}{2}$ dominates. What if the energy is such that the $I = \frac{1}{2}$ channel dominates ?

(b) **A muon neutrino is generated at time t = 0 at a particle accelerator. Show that at a latter time t the probability that it is still a muon neutrino is, in natural units and in the neutrino rest frame**

$$P_\mu(t) = 1 - \mathrm{Sin}^2 2\theta \, \mathrm{Sin}^2\left[\frac{(E_2 - E_1)t}{2}\right]$$

where

$$\nu_\mu = \nu_1 \, \mathrm{Cos}\theta + \nu_2 \, \mathrm{Sin}\theta$$
$$\nu_e = -\nu_1 \, \mathrm{Sin}\theta + \nu_2 \, \mathrm{Cos}\theta$$

and

$$\nu_1(t) = \nu_1(0) \, e^{-iE_1 t}$$

$$\nu_2(t) = \nu_2(0) \, e^{-iE_2 t}$$ 5+5
