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2017

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 scripts for Group–A and Group–B)

Group–A

Answer Q.No. *1, 2* and any *two* from the rest

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

(a) According to the shell model, find the ground state of $_8O^{15}$ nucleus.

(b) If E_o is the total energy given up by the nucleus, then prove that in β-decay, the number of emitted electrons with momentum p and energy E is proportional to $p^2(E_o - E)^2$.

(Turn Over)

(c) The absorption coefficient of Al is $0.73\ cm^{-1}$ for X-rays of λ = 0.20 A° and the density of Al is 2.7 gm/c.c. Calculate the mass absorption Coefficient.

(d) ${}_{94}Pu^{240} \rightarrow {}_{92}U^{236} + {}_{2}He^{4}$

The emitted α-particle has kinetic energy is 5.17 Mev. Calculate the disintegration energy.

(e) A beam of protons moves through a material whose refractive index is 1.8. Cerenkov light is emitted at an angle of 11° to the beam. Find the kinetic energy of the proton in Mev. ($\cos 11^{o} = 0.981$)

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

(g) Prove that Pressure of nucleons in Fermi gas model,

$P = \frac{2}{5}\rho_n E_F$, where ρ_n is the nucleon density.

(h) Calculate the expected shell-model quadruple moment of $^{209}Bi_{9/2}$.

(i) Show that a positron and an electron cannot annihilate into one photon.

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

(a) From the mass-spectroscopic doublet

$$C^{12}O_2^{16} - C^{12}S^{32} = 17.78 \times 10^{-3}\ amu$$
$$C_8^{12}H_2^{1} - C^{12}O_2^{16} = 72.97 \times 10^{-3}\ amu$$
$$C_6^{12}H_4^{1} - C^{12}S_2^{32} = 87.33 \times 10^{-3}\ amu$$

Calculate the mass of hydrogen in (amu).

(b) Calculate the fractional loss of energy of a neutron colliding with (i) proton (ii) a deuteron.

(c) In the Kurie plot of the decay of the neutron, the end point energy of the electron is 0.79 Mev. What is the threshold energy required by an antineutrino for the inverse reaction $\bar{\nu} + p \rightarrow n + e^{+}$.

(d) Plot graphically to compare energy losses by a charged particle through ionization and radiation.

${}_{9}F^{19} + n \rightarrow {}_{8}O^{19} + p - 3.9$ Mev.

Calculate the threshold energy for this reaction.

3. (a) Chlorine −33 decays by positron emission with a maximum energy of 4.3 Mev. Calculate the radius of the nucleus from this.

(End point energy of e is 0.79 Mev.)

(b) Using the semi-empirical binding energy formula, find the atomic number of the most stable nucleus for a given mass number A. Hence explain which is the most stable among $_2He^6$, $_4Be^6$, $_3Li^6$.

$p \rightarrow n + e^+$

why this reaction is not allowed? 4+4+2

4. (a) $_4Be^7 \rightarrow {}_3Li^7$

Examine the possibilities of isomeric transitions. 3

(b) Assuming that internuclear potential in deuteron to be of rectangular well type of depth V_0 and range r_0, show that radius of the deuteron is

$\frac{2r_o}{\pi}\sqrt{\frac{V_o}{E_B}}$ If B.E. of deuteron is $E_B \ll V_0$. 4

(c) Calculate the angular momentum and parity of $_7N^{16}$. 3

5. (a) Proton of K.E. 5 Mev are made to bombard a tritium target. Calculate the K.E. of neutrons emitted at an angle of (i) 60°, (ii) 90°, (iii) 180° to the incident beam in the reaction.

$$_1H^1 + {}_1H^3 \rightarrow {}_2He^3 + {}_0n^1 + Q$$

given :

$m({}_1H^1) = 1.00728$ amu $m({}_2He^3) = 3.01605$ amu

$m({}_1H^3) = 3.01605$ amu $m({}_0n^1) = 1.00870$ amu

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(b) Find the minimum energy of an anti-neutrino to produce the reaction

$$\bar{\nu}_e + p \rightarrow n + e^+$$ 3

6. (a) Discuss different exchnage forces for B.E. of nucleus.

(b) The cross section of Cd^{113} for capturing thermal neutron is 2×10^4b. Mean atomic mass of natural Cd is 112 amu and its density is 8.64×10^3 Kg/m^3.

(i) What fraction of an incident beam of thermal neutrons is absorbed by a Cd sheet of 0.1mm thick.

(ii) What thickness of Cd is needed to absorb 99% of an incident beam to thermal neutrons?

(Cd^{113} contains 12% of natural Cd). 5+5

Group–B

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

1. Answer any *five* bits : 5×3

(a) Give examples of Leptonic, semi-leptonic and non-leptonic decays.

(b) Draw the Feynman diagram for muon-electron scattering and its scattering amplitude.

(c) Classify the following interactions with explanations:

$e^+ + e^- \to \mu^+ + \mu^-$

$\pi^- + p \to K^o + \Sigma^o$

$p \to n + e^+ + \nu_e$

(d) Show that the current $j_\mu = \frac{-i}{2}(\phi\partial_\mu\phi^* - \phi^*\partial_\mu\phi)$ satisfies the continuity equation.

(e) Prove that $\not{a}^2 = a^2$

(f) Define G-parity. Show that $^3S_1(p\bar{n}) \to n\pi$ requires that the number of pions should be even

(g) Given that the ρ-meson has a width of 158 MeV/c^2 in its mass. How would you classify the interaction for its decay?

(h) In which isospin states can (i) $\pi^+\ \pi^-\ \pi^0$ (ii) $\pi^0\pi^0\pi^0$ exist?

2. (a) Assuming the principle of charge independence in pion-nucleon scattering

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

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

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

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

(b) Calculate the branching ratio for the decay of the resonance $\Delta^+(1232)$ which has two decay modes

$\Delta^+ \to p\pi^0$

$\to n\pi^+$ 5+5

3. (a) For photon field show that :

$$\left[A^\mu\left(t, \vec{x}\right), \dot{A}^\nu\left(t, \vec{y}\right)\right] = -ig^{\mu\nu}\delta^{(3)}\left(\vec{x} - \vec{y}\right)$$

(b) Find the commutator

$i D^{\mu\nu}(x-y) = \left[A^\mu(x), A^\nu(y)\right]$ in the Lorentz gauge. 5+5

4. (a) Calculate $\mathrm{Tr}\left[\not{a}\gamma^\mu\not{b}\gamma^\nu\right]$

(b) The Lagrangian density of a spinless Schrödinger field ψ is given by $\infty = i\psi^+\frac{\partial\psi}{\partial t} - \frac{1}{2m}\nabla\psi^+.\nabla\psi - V(\vec{r})\psi^+\psi$

Calculate the Green function

$$G(x_o, \vec{x}, y_o, \vec{y}) = -i\langle o|\psi(x_o, \vec{x})\psi^+(y_o, \vec{y})|o\rangle \cdot \theta(x_o - y_o)$$

(c) If $\infty = \bar{\psi}(i\gamma^{\mu}\partial_{\mu} - m)\psi$ show that $\infty^{+} \neq \infty$ for Dirac Lagrangian density. 3+3+4

5. (a) It is observed that the cross section for neutrino-electron scattering falls by 20% as the momentum transfer increases from very small values to 30 GeV/c. Deduce the mass of the exchanged boson.

(b) Estimate the number of $W^+ \rightarrow e^+ \nu_e$ events produced in $10^9 p\bar{p}$ interactions.

[Given $\sigma(p\bar{p} \rightarrow w^+)$ = 1.8nb

and $\sigma(p\bar{p} \rightarrow \text{anythings}) = 70\text{mb}$.]

(c) State and prove CPT Theorem 3+3+4
