2017

M.Sc. 4th Semester Examination

PHYSICS

PAPER—PHS-402

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) Classify neutron according to energy scale.

(b) There is a spin-orbit term $\vec{L}.\vec{S}$ in the nucleon-nucleon interaction. Explain why there can not be a term like $\vec{r}.\vec{L}$?

(c) A $D_{5/2}$ term in the optical spectrum of $^{39}_{19}K$ has a hyperfine structure with four components. Find the spin of the nucleus.

(d) Estimate the ratios of the major to minor axes of $_{73}Ta^{181}$ and $_{51}Sb^{123}$. The quadrupole moments are $+6\times10^{-24}$ cm^2 for Ta and -1.2×10^{-24} cm^2 for Sb (Take $R = 1.5A^{1/3}$ fm)

(e) Compute the expected shell-model quadruple moment of $^{209}Bi_{\left(9/2^-\right)}$.

(f) Calculate the energy of protons detected at 90° when 2.1 Mev deuterons are incident on ^{27}Al to produce ^{28}Al with an energy difference Q = 5.5 Mev.

(g) Define Fermi age and write down the Fermi-age equation.

(h) Why are dineutron and diproton unbound but not deuteron ?

2. (a) Using square well potential and appropriate boundary conditions find the wave function of the bound state of deuteron. Represent it graphically. Find a relation between range and depth of the potential. 3+1+2

(b) Prove that n and p stay outside the range of nuclear forces approximately 70% of time. 4

3. (a) ^{13}N is a positron emitter with an end point energy of 1.2 Mev. Determine the threshold of the reaction $p + {}^{13}C \rightarrow {}^{13}N + n$, if the neutron-hydrogen atom mass difference is 0.78 Mev.

(b) Derive and discuss the four factor formula for nuclear reactors.

(c) If the elastic scattering of neutrons by hydrogen nuclei is isotropic in the centre of mass system, show that

$$\overline{\ln\left(E_1/E_2\right)} = 1$$

where E_1 and E_2 are respectively the kinetic energies of a neutron before and after collision. 4+3+3

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Group-B

[Marks : 20]

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

1. Answer any *five* bits : 5×2

(a) Deduce inhomogeneous Maxwell's equations from the Lagrangian density $\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - j_\mu A^\mu$

where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$.

(b) Define momentum for a real scalar field and Dirac field.

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

(d) Prove that $\sigma_{\mu\nu}{}^+ = \gamma_0\sigma_{\mu\nu}\gamma_0$

where $\sigma_{\mu\nu} = \frac{i}{2}\left[\gamma_\mu, \gamma_\nu\right]$.

(e) Prove that $F_{\mu\nu}F^{*\mu\nu} = -4\,\vec{E}.\vec{B}$

where $F_{\mu\nu} = \left(\partial_\mu A^\nu - \partial_\nu A^\mu\right)$.

(f) If $\gamma_5 = -i\gamma_0\gamma_1\gamma_2\gamma_3$
Prove that $\mathrm{tr}(\gamma_5\gamma_\mu) = 0$.

(g) In the Glashow-Salam-Weinberg model the Feynman diagrams are possible for the process $\nu e + e^- \to \nu e + e^-$ due to the charged current as well as the neutral current — Explain.

(h) For Dirac field the energy-momentum tensor is given by

$$T^{\mu\nu} = i\bar{\psi}\gamma^\mu\partial^\nu\psi - \alpha g^{\mu\nu}$$

Find Noether current for spinor field.

2. (a) For a complex scalar field

$$\phi(x) = \frac{1}{(2\pi)^{3/2}} \int \frac{d^3\vec{k}}{\sqrt{2w_k}} \left(a\left(\vec{k}\right) e^{-ik.x} + b^+\left(\vec{k}\right) e^{-ik.x} \right)$$

Calculate the energy : H : , momentum $:\vec{p}:$ and charge : Q : 2+2+2

(b) Show that the vacuum expectation value of the scalar field Hamiltonian is given by

$$\langle 0|H|0\rangle = -\frac{1}{4}\pi m^4 \delta^{(3)}(0)\Gamma(-2). \qquad 4$$

3. (a) Draw the Feynman diagram for $\bar{e} - \bar{e}$ scattering and write the expression for scattering amplitude.

(b) Prove that $\mathrm{Tr}\left[(\not{a} + m)\gamma_\nu(\not{b} + m)\gamma_\mu\right]$

$$= 4\left[a_\nu b_\mu + b_\nu a_\mu - g_{\mu\nu}\left(a.b - m^2\right)\right]. \qquad 2+3$$

(c) Explain the spontaneous symmetry mechanism and discuss the role of the scalar boson of zero electric charge in generating masses of the gange bosons and other particles. Is this particle discovered ? 1+3+1

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