2017

M.Sc.

4th Semester Examination

PHYSICS

PAPER – PGS-402 (Gr. – A + B)

Full Marks : 50

Time : 2 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.

(Gr. A –*Nuclear Physics-II*)

Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 5 X 2 = 10

(i) Find the ground sate spin and parities of $^{33}_{16}$Si & $^{63}_{29}$Cu using shell model.

(ii) Write down the compound nucleus theory of Bohr.

(iii) Identify the unknown particle in the reaction given below using the conservation laws.

$$\pi^- + p \rightarrow k^0 + ?$$

(iv) Prove the condition $\frac{Z^2}{A} \leq 50$ for the stability of the nucleus against spontaneous fission.

(v) Find the relation between refractive index and scattering length for the neutron wave falls on a moderator.

(vi) Why heavy materials can not be good moderators?

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

(Turn over)

(viii) How do you prove that υ_e and υ_μ are different particles?

2. (a) Show that total spin-orbit splitting $\Delta E_{nl}\left(j = l - \frac{1}{2}\right) - \Delta E_{nl}\left(j = l + \frac{1}{2}\right)$ is proportional to $(2l+1)$ where the symbols have their usual meaning. (3)

(b) Assuming the deuteron to be bound in the ground state by a square well potential of depth V_0 and range b, show that the radius of deuteron is given by, $r_d = \frac{2bV_0^{1/2}}{\pi(B)^{1/2}}$, where B= B.E. of deuteron. (3)

(c) Give a brief experimental proof of Bohr's independence hypothesis. (4)

3. (a) Find the expression for the threshold energy of an endo-thermic reaction when the product particle scattered at an angle θ. (5)

(b) Explain how magic numbers are obtained considering spin-orbit potential. (5)

(Gr. B – *Quantum field theory*)

Answer Q1 and any one from Q2 and Q3.

1. Answer any five bits: 5 X 2 = 10

(i) Define Green function of QFT.

(ii) State Wick's theorem for QFT.

(iii) Show that for the odd number of fields, vacuum expectation value (VEV) of time ordered product of the field operators vanishes.

(iv) Show that the Dirac Lagrangian $\mathcal{L} = \bar{\Psi}\left(i\gamma^\mu\partial_\mu - m\right)\Psi$ is not Hermitian.

(v) Write down the Feynman diagram from the following terms:

i) $\frac{(-i\delta m^2)^2}{2}\int d^4y_1 d^4y_2\, i\Delta_F(x_1 - y_1)\, i\Delta_F(y_1 - x_2) i\Delta_F(y_2 - y_2)$

ii) $\frac{(-ig)^2}{2}\int d^4y_1 d^4y_2\, i\Delta_F(x_1 - y_1)\, i\Delta_F(y_1 - x_2) i\Delta_F(y_1 - y_2) i\Delta_F(y_2 - y_2)$

(vi) Prove that $\gamma_\mu\gamma^\upsilon\gamma^\mu = -2\,\gamma^\upsilon$

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(vii) Find the Euler-Lagrange equation for $\mathcal{L} = \frac{1}{2}\left(\partial_\mu\varphi\right)\left(\partial^\mu\varphi\right) - \frac{1}{2}m^2\varphi^2 - \frac{1}{2}\lambda\varphi^4$.

(viii) Find the commutator $iD^{\mu\upsilon}(x-y) = [A^\mu(x), A^\upsilon(y)]$ in the Lorentz gauge.

2.(a) Show that $\left[a(k,\lambda),\ a^+(k^{'},\lambda^{'})\right] = \delta^3(\vec{k} - \vec{k^{'}})\delta_{\lambda\lambda^{'}}$ for electromagnetic fields, where $a(k,\lambda) = \frac{1}{(2\pi)^{3/2}}\int \frac{d^3x e^{ik.x}}{\sqrt{2w_k}} \vec{\in}(k,\lambda).\left[w_k\vec{A}(x) + i\dot{\vec{A}}(x)\right]$ with $\vec{\in}(k,\lambda)$ is polarization vector. (6)

(b) Prove the Wick's theorem for 3 bosonic operators. (4)

3.(a) Calculate the Feynman propagator for two Fermionic fields. (6)

(b) State and prove Noether's theorem. (4)

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(Internal Assessment – 10)