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MSC/IVS/PHY/PH2202 A&B/08

2008

PHYSICS

PAPER—PH 2202 A & B

Full Marks : 40

Time : 2 hours

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

GROUP—A

(*Nuclear Physics*)

[*Marks* : 20]

Attempt *all* questions

(*Turn Over*)

1. Answer any *five* from the following: 2x5

(*a*) State the possible two-body exchange forces between nucleons.

(*b*) Set up the wave equation for the ground state of the deuteron.

(*c*) What are the Fissile and Fertiles materials ?

(*d*) What are the evidences to explain the magic numbers ?

(*e*) What are the experimental evidences in supports of the nuclear shell structure ?

(*f*) What is compound nucleus hypothesis for nuclear reaction ?

(*g*) From the fundamental concept of neutron optics write the relation between refractive index (*n*) and scattering length (*a*) of a material due to neutron.

(*h*) Compare the spin and parity predicted by the extreme single particle shell model for the ground states of the nuclei with the experimental values given in the parenthesis.

$${}_{9}\mathrm{F}^{17} \quad \left(\frac{5}{2}^{+}\right)$$

2. Answer any *one* bit: 10×1

(*a*) Using an interaction in the form of an attractive square well potential of depth U_0 and range r, obtain an expression connecting these parameters with the binding energy (B) of deuteron. 10

(*b*) Discuss graphically how Bohr - Wheeler used the liquid-drop model to explain the process of nuclear fission. Show how far this model is successful in explaining why U^{235} is fissile to slow neutrons but U^{238} is not. 8 + 2

GROUP—B

(*Quantum Field Theory*)

[*Marks* : 20]

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

1. Justify any *four* of the following statements with reasoning and derivation wherever possible: $2\frac{1}{2}\times 4$

(*a*) If ϕ is an eigenfunction of the number operator N_k, then show that $a_k\phi$ and $a_k^+\phi$ are also the eigenfunction of the operator N_k.

(*b*) Show that the energy-momentum tensor density defined by

$$T_{\mu\nu} = -\frac{\partial\phi}{\partial x_\mu}\frac{\partial \mathscr{L}}{\partial(\partial_\nu\phi)} + \mathscr{L}\,\delta_{\mu\nu}$$

satisfies the continuity equation $\frac{\partial T_{\mu\nu}}{\partial x_\mu} = 0$ assuming E - L equation for ϕ.

(*c*) Write the physical significance of Feynman graph technique.

(*d*) Prove that

$$\left[\, \phi(\vec{x}, t), \pi(\vec{x}', t) \right] = i\hbar\, \delta^3\left(\vec{x} - \vec{x}'\right).$$

(*e*) Draw Feynman diagram for a process mediated by the weak neutral gauge boson.

(*f*) Define Normal ordering and state its importance.

(*g*) Write down the Lagrangian density of the complex scalar field and obtain the field equation.

2. (*a*) Given the Lagrangian density $\mathscr{L}\ \left(\phi(x),\ \partial_\mu \phi(x)\right)$, obtain the Euler – Lagrange's equation of motion from the Hamilton's principle of least action.

(*b*) State Noether's theorem. Show that the invariance of the Lagrangian under space–time translation leads to the conserved energy momentum tensor

$$T_\mu^\nu = \frac{\partial \mathscr{L}}{\partial(\partial_\mu \phi)} \partial^\nu \phi - \delta_\nu^\mu\ \mathscr{L}.$$

4 + (1 + 5)

3. (*a*) Assuming invariance of the Dirac equation under parity operation obtain the operator for the Dirac Spinor.

   (*b*) Show that the Lagrangian density is invariant under a global gauge transformation leads to a conservation law. What is the conserved quantity ?

   (*c*) Outline the basic concepts of the Glashow - Salam - Weinberg model involving the leptons , quarks , gauge bosons and scalars indicating the gauge-symmetries involved.

$3 + (2 + 1) + 4$