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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]

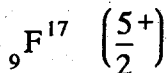
Attempt *all* questions

(Turn Over)

1. Answer any *five* from the following: 2 × 5

- (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.



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 $a_k^\dagger \phi$ are also the eigenfunction of the operator N_k .

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

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

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

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

(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 $\mathcal{L}(\phi(x), \partial_\mu \phi(x))$, 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

$$T_\mu^\nu = \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi)} \partial^\nu \phi - \delta_\mu^\nu \mathcal{L}. \quad 4 + (1 + 5)$$

(6)

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.

$$3 + (2 + 1) + 4$$