PG/IVS/PHS/402.1&402.2

/25

M. Sc. 4th Semester Examination, 2025

PHYSICS

PAPER — PHS-402.1 & 402.2

Full Marks : 50

Time : 2 hours

Answer **all** questions

The figures in the right hand margin indicate marks

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

PAPER — PHS-402.1

(*Statistical Mechanics-II*)

[*Marks* : 20]

1. Answer any *two* questions : 2×2

   (a) Find an expression of total number of particles of thin film (2D) obeying B.E. statistics.

(b) For jth mode of vibration dispersion relation $w_j = \sqrt{\dfrac{4k}{m}} \sin\left(\dfrac{j\pi}{2N}\right)$

Find the density of states.

(c) Write down an expression of photoelectric current density for $\hbar w \gg \phi$.

(d) Write down Fluctuation- dissipation theorem.

2. Answer any *two* questions : 4×2

(a) In Landau theory of diamagnetion, write down an expression of grand partition function and show that $\bar{N} = \dfrac{zV}{\lambda^3} \dfrac{x}{\sinh x}$

where $x = \dfrac{heH}{2\pi K_B Tm}$ and other symbols have usual meanings.

(3)

(b) In Bragg willian approximation show that Long range order parameter near T_c,

$$L \simeq \left[\frac{3(T_c - T)}{T} \right]^{\frac{1}{2}} .$$

(c) Find a expression of photoelectric current density for $\hbar w \langle$ work function (ϕ).

(d) Prove that for degenerate electron gas pressure $P = \frac{2}{5} n \, E_f(0)$.

3. Answer any *one* question : 8×1

(a) In ID using chain of N sites,

$$H = -J_1 \sum_{i=1}^{N-1} S_i \, S_{i+1} - J_2 \sum_{i=1}^{N-2} S_i \, S_{i+2}$$

Find the correlation function $\langle S_i \, S_{i+1} \rangle$ for $N \to \infty$.

(b) For 3D gas of bosons, single particle energy

$$\in (p,n) = \frac{|p|^2}{2m} + An ,$$

Where A is a positive constant and $n = -j$ to j is an integer. Find an expression of $\bar{N}/V$ and the condition of B.E. condensation.

[Internal Assessment — 05 Marks]

PAPER — PHS-402.2

(Nuclear Physics)

[Marks : 20]

1. Answer any *two* questions : 2×2

   (a) Show that the scattering angles of neutron in both L-system and C-system are almost same if the collision is against a very heavy nucleus.

(b) Present graphically how Bohr-Wheeler used the liquid-drop model to explain the process of nuclear fission reaction.

(c) How would the limitations of liquid-drop model be resolved in the single-particle nuclear shell model ?

(d) Write the disadvantages of nuclear reactor as a neutron source.

2. Answer any *two* questions : 4×2

(a) (i) Find the spin, parity and magnetic-moment of $_{16}S^{33}$ nuclide using nuclear shell model.

(ii) Show that the maximum loss of energy in a single collision of neutron with the moderator nucleus is proportional to the initial energy of the neutron. $2 + 2$

(b) (i) The compound nucleus can become de-excited either through γ-emission or by fission into nuclear fragments. The mean life-time of the compound nucleus is found to be 4.7×10^{-15} sec and the partial width for γ-emission is $\Gamma_\gamma = 3.4 \times 10^{-2} \, eV$. Find the partial fission width of Γ_γ for the emission of fragment γ.

(ii) How can you establish that neutrons at low energy behave like a gas ? 2 + 2

(c) Write a short note on a crystal monochromator for neutrons. 4

(d) (i) In case of harmonic oscillator nuclear shell model, establish the relation between the harmonic oscillator frequency and the nuclear mass number.

(*Continued*)

(*ii*) What are the experimental evidences in supports of the nuclear shell structure ?   3 + 1

3. Answer any *one* question :   8 × 1

(*a*) (*i*) The neutron and proton in a deuteron nucleus interact through a square-well potential of width $b = 1.9 \times 10^{-15}\, m$ and depth $V_0 = 40\, MeV$ in the $l = 0$ state. Calculate the probability that the proton moves within the range of the neutron. Use the approximation that $m_n = m_p = m$ and $kb = \pi/2$,

where $k = \sqrt{m\left(V_0 - \epsilon_d\right)}/\hbar$ and ϵ_d is the binding energy of the deuteron. Also, find the mean-square radius of the deuteron nucleus.

(*ii*) How can you establish that neutrons at low energy behave like a gas ? 5 + 3

(b) (i) Find the expression for threshold energy (E_{th}) for an endoergic nuclear reaction. Hence, show that

$$\left(E_{th}\right)_{\theta=0^\circ} = -Q.\left(1 + m_x / M_X\right)$$

Symbols have their usual meanings.

(ii) In case of the scattering of thermal neutrons wave with matter, find the expression for the refractive index of matter.   5 + 3

[Internal Assessment — 05 Marks]