2024
M.Sc.
4th Semester Examination
PHYSICS
PAPER – PHS-402
Full Marks: 50
Time: 2 Hours

Paper code: 402.1 (Statistical Mechanics - II)

ANSWER Q1, Q2, AND ANY ONE FROM Q3 AND Q4

1. **Answer any two (02) from the following:** **2×2=4**

a) Show that $z\,(\partial f_\gamma(z)/\partial z) = f_{(\gamma-1)}(z)$, where $f_\gamma(z)$ are Fermi-Dirac functions.
b) Plot the nature of variation of order parameter with temperature for the first-order and second-order phase transitions. Which physical quantity is identified as the order parameter of a magnetic system?
c) Discuss the concept of degeneracy and explain how it affects the behaviour of an ideal Fermi gas.
d) Write the grand partition functions of an ideal Fermi gas and an ideal Bose gas.

2. **Answer any two (02) from the following:** **2×4=8**

a) Obtain the expression for critical temperature (T_c) for Bose-Einstein condensation. Plot the variation of N_0/N and N_e/N with T/T_c. 3+1

b) Starting from the following relations for the free Bose gas

$\frac{P}{kT} = \frac{g_{5/2}(z)}{\lambda^3}$ and $\frac{N-N_0}{V} = \frac{g_{3/2}(z)}{\lambda^3}$

$U = \frac{3}{2} KT \frac{V}{\lambda^3} g_{5/2}(z)$

Calculate specific heat for $T>T_c$.

c) For a highly degenerate electron gas obtain the expression for low field susceptibility at absolute temperature.

d) Show that the fluctuations in the number density (n) in grand canonical ensemble can be expressed as $\langle n^2\rangle - \langle n\rangle^2 = \frac{k_B T}{V^2}\frac{\partial}{\partial \mu}\langle n\rangle$.

(Turn Over)

3. For a one-dimensional Ising system of N spins in a field h, determine the partition function in terms of eigenvalues of the matrix.

$$\begin{pmatrix} e^{\beta(J+h)} & e^{-\beta J} \\ e^{-\beta J} & e^{\beta(J-h)} \end{pmatrix}$$

a) Show that only large eigenvalue will contribute to the free energy.
b) Further show that at zero magnetic field the magnetisation is zero for all temperatures. 4+4

4. a) What are Landau Levels?
b) de Haas-van Alphen effect describes a phenomenon that happens to electrons in metals under external magnetic field B. Explain this phenomenon and derive the expression for magnetic susceptibility (χ). Plot the variation of χ with B. 2+(2+3+1)

Paper code: 402.2 (Nuclear Physics - II)

ANSWER Q1, Q2, AND ANY ONE FROM Q3 AND Q4

1. **Answer any two (02) of the following:** **2×2=4**

a) Write down the essential differences between *p-p* and *p-n* low energy scattering.

b) Draw the energy states due to 2-phonon quadrupole type of nuclear vibration.

c) State the Bohr's independence hypothesis of compound nuclear reaction.

d) What are stripping and pickup nuclear reactions?

2. **Answer any Two (02) of the following:** **2×4=8**

a) What are magic numbers? Write down experimental evidences for nuclear shell effect. (1+3)

b) What is threshold energy in nuclear reaction? Derive it. (1+3)

c) Discuss the spin-orbit coupling in nuclear shell model. (4)

d) Discuss the Bohr-Wheeler theory of nuclear fission. (4)

3. What is moderator in nuclear reactor? Discuss slowing down of neutron in moderator and calculate the average energy loss per collision. (1+2+5)

4. Calculate the magnetic dipole moments for $l = 0$ and $l = 2$ cases for bound state of deuteron. Show that the contributions of $l = 0$ and $l = 2$ are 96% and 4% for the bound state of deuteron, respectively. (4+4)

(All the symbols have their usual meanings)

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Internal Assessment-10