Reg. No ..... Name **25P2052**

M. Sc. DEGREE END SEMESTER EXAMINATION - APRIL 2025

SEMESTER 2 : PHYSICS

COURSE : **24P2PHYT08 : THERMODYNAMICS AND STATISTICAL MECHANICS**

(For Regular - 2024 Admission)

Time : Three Hours Max. Weights: 30

PART A

Answer any 8 questions **Weight: 1**

1. What is the role of chemical potential in a system with variable particle number? (U)
2. Two independent systems A and B undergo an approach to mechanical equilibrium. Obtain the expression for the rate of change of entropy with time. (U)
3. What is the microscopic basis for entropy? (U)
4. What is the grand canonical ensemble? (U)
5. Discuss the change in Boltzmann's probability distribution when heat is added to the system but no work is done on the system. (U)
6. Write down the expression for density of states D(k)dk for a single particle in 2 dimensions. (U)
7. Explain symmetry breaking in phase transitions. (U)
8. Obtain the expression for free energy at low temperatures for a diatomic molecule having rotational motion alone. (U)
9. Show that total work done in an isothermal expansion process for an ideal gas is given as $-RT \ln(V_2/V_1)$ (A)
10. Give an example of a Fermi system. (U)

(1 x 8 = 8)

PART B

Answer any 6 questions **Weights: 2**

11. A manufacturer knows that their resistors have values which are distributed as a Gaussian probability distribution with a mean resistance of 100Ω and standard deviation of 5Ω. What percentage of resistors have resistances between 95 and 105Ω. (A)
12. In sodium there are about 2.6×10^{28} conduction electrons per cubic meter which behave as a free electron gas. From these facts estimate the Fermi energy of the gas and an approximate value of the molar specific heat capacity at 300 K. (A)
13. Discuss methods of calculating the chemical potentials. (U)
14. Calculate the free energy of a system with spin one on each site, given that the levels associated with the three spin states have energies ε, 0 and – ε. (A)
15. Give Bose derivation of Plank's law. Using this, show that the Stefan's constant is given by $\sigma=2\pi^5k^4/(15c^2h^3)$? (A)
16. Derive Planck's distribution law. (U)

17. Assume that the heat capacity at constant volume of a metal varies as ($aT + bT^3$) for low temperature. Calculate the variation of the entropy with temperature. (A)

18. Show that the Helmholtz free energy of a set of N localized particles, each of which can exist in levels of energy 0, ε, 2 ε and 3 ε having degeneracies 1, 3, 3 and 1 respectively is $-3Nk_BT \ln(1+\exp(-\varepsilon/k_BT))$ (A)

(2 x 6 = 12)

PART C

Answer any 2 questions **Weights: 5**

19. Show that among engines operating between the same 2 temperatures, the Carnot engine is the most efficient. (U)

20. Show that the pressure due to a black body radiation is given as <U>/ (3xVolume). (U)

21. Obtain the expression for density of states for a single free particle in 3 Dimension. (U)

22. Obtain the general expression for entropy for a diatomic molecule possessing vibrational motion alone. (U)

(5 x 2 = 10)

OBE: Questions to Course Outcome Mapping

CO	Course Outcome Description	CL	Questions	Total Wt.

Cognitive Level (CL): Cr - CREATE; E - EVALUATE; An - ANALYZE; A - APPLY; U - UNDERSTAND; R - REMEMBER;