TM252572M

Reg. No :.....

Name :.....

MASTER'S DEGREE (C.S.S) EXAMINATION, MARCH 2025

2020, 2021, 2022, 2023 ADMISSIONS SUPPLEMENTARY

SEMESTER II - CORE COURSE PHYSICS

PH2C07TM20 - Thermodynamics and Statistical Mechanics

Time : 3 Hours **Maximum Weight : 30**

Part A

I. Answer any Eight questions. Each question carries 1 weight **(8x1=8)**

1. Establish that no irreversible machine is more efficient than the Carnot machine.
2. State and explain zeroth law and third law of thermodynamics.
3. Distinguish between simple and compound events. Cite examples for each.
4. State and explain equipartition theorem.
5. By constructing the expression for wave function in determinant form, show that it is impossible to put two Fermi particles in the same single-particle state.
6. Show that the internal energy density of black body radiation is proportional to the fourth power of temperature.
7. Take the radiation from the Sun to be black- body radiation with a maximum in u(λ) at 480 nm. Estimate the temperature of the Sun.
8. Obtain the equation representing the condition for chemical equilibrium.
9. Deduce the expression for internal energy for a Fermi gas at absolute zero of temperature.
10. Define symmetric breaking field and estimate the critical exponents γ and δ.

Part B

II. Answer any Six questions. Each question carries 2 weight **(6x2=12)**

11. a)Obtain the relation between heat capacity at constant volume and that at constant pressure for an ideal monoatomic gas. b) A hot water tank contains 200kg of water at 45^0C. How much heat is needed to raise the temperature to 70^0C. Specific heat capacity of water is 4200J Kg^{-1} K^{-1}.
12. If 10^{-7} J of heat is added to a system that is so large that its temperature does not change, by what factor will the number of accessible states of the system increase if the temperature is 30K?
13. A system has two energy levels with an energy gap of 3.2×10^{-21} J; the upper level is two fold degenerate, the lower level is non-degenerate. Estimate the probability that the lower level is occupied if the system is in thermal contact with a heat bath at a temperature of 150 K?
14. Calculate the free energy of a system with N particles, each with spin $\frac{3}{2}$ with one particle per state, given that the levels associated with the four spin states have energies $\frac{3}{2}\varepsilon$, $\frac{1}{2}\varepsilon, -\frac{1}{2}\varepsilon$ and $-\frac{3}{2}\varepsilon$ and degeneracies 1,3, 3, and 1 respectively.
15. Calculate the partition function for a relativistic particle (p≫mc) in one dimension.
16. The partition function for an ideal gas of N atoms is approximately $Z_N = \frac{{Z_1}^N}{N!}$. Show, for example by considering the power series expansion of $e^{\lambda Z_1}$ where λ is equal to $e^{\mu/k_B T}$, that the grand partition function for this gas is $\Xi = e^{\lambda Z_1}$.
17. Express the relationship between the mass of a star and its radius for the formation of a white dwarf star.
18. Deduce the expression for Helmholtz free energy for phase separation in mixtures.

Part C

III. Answer any Two questions. Each question carries 5 weight **(2x5=10)**

19. Discuss the Carnot cycle and other composite engines and their efficiencies. Hence establish the relationship of absolute temperature with the perfect gas scale of temperature.
20. Considering the translational motion of N non-interacting particles in three dimensions show that the contribution to specific heat capacity is $C_v = \frac{3}{2}Nk_B$.
21. Starting from Boltzmann's probability distribution obtain the expression for Maxwell distribution of molecular speeds.
22. Explain Landau Theory for a uniaxial ferromagnet and illustrate the relevance of symmetry breaking field.