B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : C 14-T

[Statistical Mechanics]

[CBCS]

Full Marks : 40 Time : Two Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group - A

Answer any *five* questions : 2×5=10

1. Show that electron gas in a white dwarf star is strongly degenerate and relativistic in nature. 2

2. Write statistical definition of temperature in terms of accessible microstates. Assuming the number of accessible microstates $\Omega(E,V)\alpha\left(V^N E^{\frac{3N}{2}}\right)$, find the molar specific heat at constant volume. 2

3. Which among the Bose-Einstein and Fermi-Dirac statistics will be followed by (i) Neutrons, (ii) Alpha particles, (iii) Deuterium nuclei, and (iv) ${}_2He^3$ atoms? 2

P.T.O.

4. Find the Fermi energy at $T = 0k$ for metallic silver containing one free electron per atom. The density of silver is 10.5gm/cc and atomic weight of silver is 108. 2

5. What do you mean by 'ultraviolet catastrophe'? 2

6. What is 'λ-transition' in liquid Helium? 2

7. In a system 8 distinguishable particles are distributed in 2 compartments with equal a priori probability. Calculate the probabilities for the macrostates (i) (4, 4) and (ii) (3, 5). 2

8. What is Chandrasekhar limit? 2

Group - B

Answer any ***four*** questions : 5×4=20

9. What is Gibbs paradox? How is it resolved? 1+4

10. Define Saha's ionization formula and discuss one of its applications. 5

11. Explain B-E condensation in 3 dimension. How does it differ from ordinary condensation? Derive an expression for the critical temperature at which the phenomenon sets in. 5

12. For a completely degenerate Fermi gas of N molecules the density of states is given by

$$g(\varepsilon)d\varepsilon = ag_s V\varepsilon^n$$

where a and n are constants, g_s is spin degeneracy and V is the volume. Calculate the Fermi energy and total energy of the system at zero Kelvin temperature. 5

13. The specific heat of a metal (in three dimensions) at low temperatures can be represented by $C_V = aT + bT^3$, where a and b are constants. Explain the origin of the first term with necessary deduction. 5

14. Starting from Planck's law deduce (i) Rayleigh-Jeans law and (ii) Wien's law. 2½+2½

Group - C

Answer any ***one*** question : 10×1=10

15. (a) Calculate deviation of an ideal Fermi gas equation from the perfect gas equation for weak degeneracy. How is it related to gas degeneracy? 5+2

(b) An atom has a non-degenerate ground state with energy $\varepsilon_0 = 0$ and a doubly degenerate excited state with energy $\varepsilon_1 = \varepsilon$. Calculate the specific heat at very low temperature $(\beta\varepsilon >> 1)$. 3

16. Write down the single particle partition function for a system having two non-degenerate energy levels with energies : $\varepsilon_1 = -\mu H$ and $\varepsilon_2 = \mu H$. Evaluate entropy for this system. Hence discuss the concept of negative absolute temperature of such a two-level system. 4+4+2