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6 SEM TDC PHYH (CBCS) C 14

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(June/July)

PHYSICS

(Core)

Course : C-14

(**Statistical Mechanics**)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

1. Choose the correct answer from the following : 1×5=5

(a) In the equilibrium state, the thermodynamic probability of a system is

(i) zero

(ii) maximum

(iii) minimum but not 1

(iv) one

- (b) Gibbs' paradox arises due to
- (i) indistinguishability of classical particles
 - (ii) distinguishability of classical particles
 - (iii) omittance of quantum nature of the particles
 - (iv) absence of inter-particle interaction
- (c) Rayleigh-Jeans law agrees well with the experimental result at
- (i) low frequency
 - (ii) infinity
 - (iii) high frequency
 - (iv) None of the above
- (d) At high temperature, Bose-Einstein distribution approaches Maxwell-Boltzmann distribution.
- (i) False
 - (ii) True
 - (iii) Cannot say
 - (iv) Sometimes true sometimes false
- (e) From Fermi-Dirac statistics, $n_i = ?$
- (i) $\frac{g_i}{e^{\alpha + \beta \epsilon_i} + 1}$
 - (ii) $\frac{2g_i}{e^{\alpha + \beta \epsilon_i} + 1}$
 - (iii) $\frac{g_i}{e^{\alpha + \beta \epsilon_i} - 1}$
 - (iv) $\frac{2g_i}{e^{\alpha + \beta \epsilon_i} - 1}$

2. (a) Define and explain in brief the terms 'macrostate' and 'microstate' with the help of an example. 2+2=4
- (b) Define entropy. Deduce Boltzmann's entropy relation. 1+3=4
- (c) Treating the ideal gas as a system governed by classical mechanics, derive the Maxwell-Boltzmann distribution law. 6

Or

Derive the partition function for an ideal monoatomic gas.

3. (a) What do you mean by 'thermal radiation'? 2

Or

If the sun emits maximum energy at wavelength 4753 \AA , then calculate the temperature of its surface. (Given : Wien's constant $b = 0.288 \text{ cm }^\circ\text{C}$)

- (b) State and prove Kirchhoff's law of blackbody radiation. 4
- (c) State and derive Planck's law of blackbody relation. 1+4=5

Or

State Stefan-Boltzmann law of radiation. Deduce this law on thermodynamic consideration. 5

4. (a) What is photon gas? What is the difference between photon gas and ideal gas? 1+2=3

(b) What is Bose-Einstein statistics? Derive an expression

$$n_i = \frac{g_i}{e^{\alpha + \beta \epsilon_i} - 1} \quad 1+3=4$$

Or

Explain why behavior of liquid helium cannot be explained by classical statistics. How is it overcome by quantum mechanics? 4

(c) Bosons may condense at very low temperature. Discuss on the basis of statistical mechanics. 4

5. (a) At absolute zero temperature ($T = 0$ K) all the energy levels up to ϵ_f are completely filled. Calculate the total number of fermions in a Fermi gas at $T = 0$ K and express ϵ_f in terms of number density (N/V). 6

Or

Derive an expression for Fermi-Dirac law of energy distribution for free electrons in a metal.

(5)

(b) What is the cause of degeneracy pressure inside a white dwarf star? Explain the limit depending on which some stars become white dwarf and other become neutron star or black hole.

1+5=6

Or

A system has 7 particles arranged in two compartments. The first compartment has 8 cells and the second has 10 cells. All cells are of equal size. Calculate the number of microstate in the microstate (3, 4) when the particles obey F-D statistics.

6
