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6 SEM TDC PHYH (CBCS) C 14

2024

(May)

PHYSICS

(Core)

Paper : 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 option from the following : 1×5=5

(a) The thermodynamic probability of a system in equilibrium is

(i) maximum

(ii) minimum but not 1

(iii) 1

(iv) zero

(Turn Over)

(b) Rayleigh-Jeans law of radiation

(i) applies to smaller wavelengths

(ii) applies to longer wavelengths

(iii) applies to all wavelengths

(iv) does not apply to any wavelength

(c) According to which statistics, the energy at absolute zero cannot be zero?

(i) MB

(ii) BE

(iii) FD

(iv) None of the above

(d) Five particles are distributed in two-phase cells. Then the number of macrostates is

(i) 6

(ii) 10

(iii) 32

(iv) $\frac{5}{2}$

(e) Deduction of Planck's law is possible on the basis of

(i) Fermi-Dirac (FD) statistics

(ii) classical statistics

(iii) Maxwell-Boltzmann (MB) statistics

(iv) Bose-Einstein (BE) statistics

2. (a) Define statistical ensemble. Differentiate among canonical, microcanonical and grand canonical ensembles. 1+3=4

(b) Define entropy. Show that the entropy of the system is proportional to the logarithm of probability of that system. 1+3=4

(c) Show that the number of molecules in a cell of energy ε_i in the equilibrium state is given by $n_i = Ae^{-\varepsilon_i/kT}$, where A is any constant. 6

Or

Derive the expression for entropy, enthalpy and Helmholtz's free energy in terms of statistical parameters. 2+2+2=6

3. (a) State Stefan-Boltzmann law of radiation. Deduce this on the basis of thermodynamic considerations. 3

(b) What is black-body radiation? Explain its temperature dependence. 1+2=3

(c) What is Planck's law of black-body radiation? Derive an expression for it. 2+3=5

(d) State and explain Rayleigh-Jeans law. Explain its validity in terms of experimental results. 2

Or

Calculate the energy radiated by unit area of a blackbody in one second when its temperature is 1000 K. ($\sigma = 5 \cdot 672 \times 10^{-8}$ J/S/m^2)

4. (a) "Bosons may condense at very low temperature." Give a statistical mechanical interpretation. 4

Or

How many photons are present in 1 cm^3 of radiation at 727 °C?

[Given, $\int_0^\infty \frac{x^2 dx}{e^x - 1} = 2 \cdot 405$]

(b) What is photon gas? What are the properties of photon gas? 1+2=3

(c) Derive an expression $n_i = \frac{g_i}{e^{\alpha + \beta E_i} - 1}$ for the most probable distribution of the particles of a system obeying BE statistics. 4

Or

Derive the expression for energy of a strongly degenerate Bose gas.

5. (a) What is the cause of degeneracy pressure inside a white dwarf star? Explain the limit depending on which some stars become white dwarf star and other becomes neutron star or black hole. 1+4=5

Or

Derive the expressions for entropy and Helmholtz free energy of a strongly degenerate Fermi gas. 5

(b) Derive an expression for Fermi-Dirac law of energy distribution for free electrons in a metal. 5

Or

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).

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