2017

PHYSICS — HONOURS

Seventh Paper

(Group – A)

Full Marks – 50

The figures in the margin indicate full marks

Candidates are required to give their answers in their own words as far as practicable

Answer ***Question No. 1*** and ***any four*** from the rest

1. Answer ***any five*** questions : 2×5

(a) By evaluating the volume of the relevant region of its phase space, show that the number of microstates available to a rigid rotator with angular momentum less than M is $(2\pi M/h)^2$.

(b) State the theorem of equipartition of energy with particular emphasis on the form of the system's Hamiltonian.

(c) Sketch the Fermi distribution function for three temperatures $T_1 > T_2 > T_3 = 0$ on the same graph.

(d) Explain how Maxwell modified the Ampere's law.

(e) The non-zero components of the electric and magnetic vectors for an electromagnetic field are given by $E_y = E_0 e^{i(kx-\omega t+\phi)}$, $B_z = B_0 e^{i(kx-\omega t)}$ respectively. Obtain the value of ϕ, when $0 \le \phi < 2\pi$.

(f) Find out the pressure exerted by a radiation of power 1kW/cm^2 on a totally absorbing surface.

2. (a) Derive the partition function of a system of classical monatomic ideal gas. How do you show the extensive property of the entropy from this partition function ?

(b) A system has two non-degenerate energy states E_1 and E_2, with populations n_1 and n_2, respectively (n_1, $n_2 >> 1$). The system is in contact with a heat bath at temperature T. Show, from Boltzmann's statistical definition of entropy, the change in entropy when one particle goes from state 1 to state 2 is given by $k\ln(n_2/n_1)$ where k is the Boltzmann constant.

(c) A system has three non-degenerate energy states given by $\varepsilon_1 = 0\text{K}$, $\varepsilon_2/k = 200\text{K}$ and $\varepsilon_3/k = 300\text{K}$. Find the average energy $\langle\varepsilon\rangle$ and dispersion $\sigma = \sqrt{\langle\varepsilon^2\rangle - \langle\varepsilon\rangle^2}$ for the system if the temperature of the system is 250K. (3+3)+2+2

[Turn Over]

3. Find out the number of ways in which n identical bosons may be distributed among g energy levels.

Obtain an expression for electronic specific heat for metals at low temperature.

A spherical black body of radius 1cm is enclosed in an evacuated chamber. If the chamber is at a temperature 300K, find out the amount of heat that must be supplied per second to the black body to keep it at a temperature 1000K. Neglect conduction of heat, ($\sigma = 5.67 \times 10^{-8} W/m^2/K^4$). 2+4+1+3

4. (a) With proper explanation, derive the condition of validity of classical statistical mechanics in terms of the temperature and density of particles.

(b) Show that the Fermi momentum is proportional to the cube root of the density of free fermions at zero temperature in three dimensions. 5+5

5. Starting from Maxwell's equation, show that any initial charge density in a conductor dissipates in a characteristic time.

Find the average energy density for a plane monochromatic wave.

Show that Poynting theorem predicts Joule heating in a wire. 3+3+4

6. A current I is made to increase in the windings of a long solenoid very slowly. The solenoid has radius R, length L and 'n' turns per unit length.

(a) Write down the expression for energy stored U, in the solenoid at any given instant.

(b) Find out the time rate of change of U in terms of $\frac{dI}{dt}$.

(c) Use Faraday's law to find the induced electric field.

(d) Find out the instantaneous Poynting vector.

(e) Calculate its flux through the Lateral surface (i.e. the cylindrical surface, not the edges) and find its relation with $\frac{dU}{dt}$. 2+2+2+2+2

7. An electromagnetic wave is incident at the surface of two linear homogeneous dielectrics. Write down the boundary conditions at the surface. Find out the ratio of the electric field intensities for normal incidence. Find out the conditions under which there is a phase reversal for the reflected wave.

Starting from Maxwell's equations derive Kirchhoff's voltage and Current Laws. 2+3+2+3