B.Sc. S.Y. (CBCS Pattern) Semester-III

USPHT06 - Physics Paper-II : Radiation and Statistical Physics

P. Pages : 3 **GUG/W/24/11617**

Time : Three Hours * 4 5 6 9 * Max. Marks : 50

Notes : 1. All questions are compulsory.
2. Draw neat and well labelled diagrams wherever necessary.

Either:

1. A) i) State Planck's radiation law for black body radiation. Calculate average energy of Planck's oscillator and derive Planck's radiation formula form it. **5**

ii) Explain the Ultraviolet catastrophe according to Rayleigh – Jeans law. **3**

iii) What is the Wavelength of maximum intensity radiation radiated from a source at temperature 3000ºC? (Given Wien's constant = (2.898×10^{-3}mK) **2**

OR

B) a) State and explain Stefan's - Boltzmann law. **2½**

b) Explain the concept of energy density. **2½**

c) Show that Planck's law reduces to Rayleigh-Jeans law for longer wavelengths. **2½**

d) A spherical body has a radius of 0.01m. This is maintained at 873 K. Calculate the rate at which energy is radiated from the surface assuming it to be a perfectly black body. Given $\sigma = 5.672\times10^{-8}\,\mathrm{Js^{-1}m^{-2}K^{-4}}$ **2½**

Either:

2. A) i) Define Thermodynamic probability and derive the Boltzmann's entropy relation $S = k\log_e(W)$. **5**

ii) Explain the term principle of equal a priori probability. **3**

iii) Calculate the number of accessible microstates W of a system having entropy $10\,\mathrm{cal\ K^{-1}}$ in the equilibrium state. Given $1\mathrm{cal} = 4.2\times10^{7}$ ergs and Boltzmann's constant, $K = 1.38\times10^{-16}\mathrm{ergs^{-1}}$. **2**

OR

B) a) Discuss the constraints in thermodynamic system. **2½**

b) Explain macrostates and microstates with suitable example. **2½**

c) Show that the smallest volume of unit cell in phase space is h^3 where h is Planck's constant. **2½**

d) Three similar dice A, B and C each having 6 equally likely faces marked as 1, 2, 3, 4, 5, 6 are thrown simultaneously and in a toss all the faces have equal probability of appearing up. Calculate the probability of getting the faces of all the dice up marked with 1 number. **2½**

Either:

3. A) i) Derive Maxwell-Boltzmann energy distribution for gas molecules. **5**

ii) What are the fundamental postulates of statistical mechanics? **3**

iii) Calculate the value of root mean square speed of a molecule of hydrogen at 27ºC. **2**

Given : Boltzmann's constant, $K = 1.38 \times 10^{-23} J / kg.$

Mass of hydrogen molecule = 3.34×10^{-27} kg .

OR

B) a) Derive an expression for Most probable speed. **2½**

b) State the characteristics of a particle obeying M.B-statistics. **2½**

c) If the most probable speed of molecule of hydrogen is 100 m/sec at TK, calculate the most probable speed of an oxygen molecule at 2TK. **2½**

d) Show that the root mean square speed is $\nu_{rms} = \sqrt{\frac{3kT}{m}}$ **2½**

Either:

4. A) i) Derive F. D. energy distribution law for continuous variation of energy. **4**

ii) Applying F. D. distribution to electron gas, show that the distribution of energy among free electrons of a conductor is. **4**

$$x(E)dE = \frac{8\sqrt{2}\pi v}{h^3} \frac{m^{3/2}\ E^{1/2}}{e^{(E-E_F/kT)}} dE$$

iii) Fermi energy of conduction electrons in silver 5.48 eV. Calculate the number of electrons per cm^3. Given $h = 6.62 \times 10^{-27}$ erg. sec and $1eV = 1.62 \times 10^{-12}$ erg. **2**

OR

B) a) What is Fermi energy? Explain its significance. **2½**

b) Write short notes on Photon gas. **2½**

c) Give the fundamental postulates of Bose-Einstein statistics. **2½**

d) Three particles are to be distributed in four energy levels a, b, c and d. Calculate all possible ways of distribution when particles are (i) Fermions (ii) Bosons (iii) classical particles. **2½**

5. Attempt **any ten** of the followings.

a) What is black body radiation? **1**

b) State Wein's displacement law. **1**

c) State Rayliegh - Jeans Law. **1**

d) What is μ – space? **1**

e) Define the term probability. **1**

f) Find the thermodynamic probability for four distinguishable particles for the microstate (3, 1). **1**

g) Define Degeneracy parameter. **1**

h) Give the limitation of M. B. statistics. **1**

i) The speed of ten particles in m/sec is 0, 1, 2, 3, 3, 4, 4, 4, 5 and 6 respectively. What is their most probable speed? **1**

j) What are fermions? **1**

k) What is occupation index? **1**

l) Define Fermi function. **1**

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