Roll No. .....

(05/16-I)

5217

B. Sc. EXAMINATION

(Fourth Semester)

PHYSICS

Seventh Paper

Statistical Physics

Time : Three Hours *Maximum Marks : 40*

Note : Q. No. 1 is compulsory. Four more questions are to be attempted, selecting *one* question from each Unit. Use of scientific (non-programmable) calculator is allowed. Log tables may be asked for.

Compulsory Question

1. (a) What is Phonon ? 1½

   (b) What is the Statistical definition of Entropy ? 1½

   (c) What is Fermi Gas ? Give an example. 1½

   (d) Where does the Dulong and Petit's law fail ? 1½

   (e) What do you mean by Phase Space ? 1

   (f) What is the minimum size of phase space cell in classical statistics ? 1

Unit I

2. (a) Define Microstates, Macrostates, Thermodynamic probability and constraints. Differentiate between accessible states and in accessible states. Discuss the distribution of 4 particles in two compartments of equal size. 5

   (b) Derive the condition $\beta_1 = \beta_2$ for equilibrium of two systems in thermal contact. 3

3. (a) What do you mean by statistical fluctuations ? Derive an expression for the probability of a macrostate which deviates by a small amount from the most probable macrostate. 5

(b) Find the number of accessible microstates (Thermodynamic Probability) of a system having an entropy of 40 cal/Kelvin in the equilibrium state. Given :

$K = 1.38 \times 10^{-23}$ Joules/Kelvin

1 Cal = 4.2 Joule

Unit II

4. (a) The probability of a molecule having x-component of velocity in the range (v_x) and $(v_x + dv_x)$ is given by :

$$p(v_x)\,dv_x = \left(\frac{m}{1\pi KT}\right)^{3/2} e^{-\frac{mv^2}{1kT}}\, dvx$$

show that :

(i) Maximum value of $P = \left(\frac{m}{1\pi KT}\right)^{1/2}$

(ii) Average value of $\left(v_x^2\right) = \left(\frac{KT}{m}\right)$

(b) If the r.m.s. speed of molecules of Hydrogen at NTP is 1 km/sec, calculate the r.m.s. speed of oxygen molecules at N.T.P. 3

5. (a) Using the M.B. law of distribution of speeds :

$$n(v)\,dv = 4\pi n\left(\frac{m}{2\pi kT}\right)^{3/2} e^{-\frac{mv^2}{2kT}} v^2 dv$$

Find an expression for :

(i) The most probable speed

(ii) The average speed 4

(b) What are different kinds of statistics and briefly discuss the basic approach in these statistics. 4

Unit III

6. (a) Using BE distribution law, derive Planck's law for black body radiation in terms of wavelength. 5

(b) Calculate the Fermi energy for sodium assuming that it has one free electron per atom.

Given $\frac{n}{V}$ = free electron density =

26.0×10^{27} electron/m^3

7. (a) Starting from basic assumption of F.D. statistics, derive the relation :

$$n_i = \frac{g_i}{\alpha\,\beta u_i \quad ee+1}$$

(where the symbols have their usual meaning.)

and also show that in the limiting case F.D. statistics are reduced to M.B. Statistics. 5

(b) Calculate the number of different arrangement of 10 indistinguishable particles in 15 cells of equal a prior probability, considering that one cell contains only one particle. 3

Unit IV

8. (a) Derive Debye's expression from the specific heat of solids. Hence explain Debye's T^3 law. 6

(b) Explain, how the Debye's model is different from the Einstein's model of specific heat of solids. 2

9. (a) Derive an expression of Dulong and Petit's law from classical phyises. 5

(b) Find the Einstein temperature, if Einstein frequence (ν_E) is 3.0×10^{12} Hz. 3