

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

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P.T.O.

- (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 :

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

$$1 \text{ Cal} = 4.2 \text{ Joule}$$

#### 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 :

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

show that :

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

- (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 4  
(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 =  $26.0 \times 10^{27}$  electron/m<sup>3</sup>

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

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

(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 priori 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 physics. 5
- (b) Find the Einstein temperature, if Einstein frequency ( $\nu_E$ ) is  $3.0 \times 10^{12}$  Hz. 3