BACHELOR OF SCIENCE (B.Sc.)

Term-End Examination

December, 2007

PHYSICS

PHE-6 : THERMODYNAMICS & STATISTICAL MECHANICS

Time : 2 hours *Maximum Marks : 50*

Note : *Q. 1 is **compulsory**. Answer any **four** questions from the rest. Use of log tables and non-programmable calculators is allowed. Symbols have their usual meanings.*

1. Answer any ***five*** parts : 10

(i) Explain the following terms with an example each :

(a) Diathermal boundary

(b) Adiabatic boundary

(ii) State the first law of thermodynamics and write its differential form.

(iii) What is entropy ? Write the Clausius statement of the second law of thermodynamics.

(iv) Draw the phase diagram of water.

(v) Define 'degree of freedom' of a molecule. How many degrees of freedom does a point moving along a curved path on a plane have ?

(vi) Which distribution is obeyed by a particle performing a random walk ? Write down the expression for its probability.

(vii) What is 'phase space' ? If a system contains five molecules, what is the dimension of the phase space ?

2. (a) With the help of a neat labelled diagram, explain the working of a constant volume gas thermometer. 5

(b) Explain the 'fountain effect' in liquid He on the basis of superfluidity. 5

3. (a) 10 g of water at 100° C changes into steam to occupy a volume of 2000 cc at atmospheric pressure. Calculate (i) the work done in joules and (ii) the change in internal energy. 5

[Given latent heat of steam = 540 cal g^{-1} and 1 atm = $1{\cdot}01 \times 10^5$ Nm^{-2}]

(b) Derive the expression for the partition function for an N-particle ideal gas. 5

4. (a) A 2 kg metal block with specific heat capacity of 400 J kg^{-1} K^{-1} is heated from 200 K to 400 K. Calculate the entropy change of the block, assuming irreversible heat transfer. 5

(b) State three assumptions made while modifying the ideal gas equation to real gas equation by Van der Waals. Write down this equation explaining the significance of each term. 3+2

5. (a) A gas obeys the equation $p\,(V - b) = RT$, where b is a constant. Show that

(i) the internal energy of the gas is a function of T only;

(ii) the ratio of specific heat capacities of the gas is constant. 2+3

(b) Derive the expression for the diffusion coefficient D for the displacement of Brownian particles from the random molecular motion. 5

6. (a) Describe the experimental set-up of adiabatic demagnetisation for the production of low temperatures. 5

(b) Calculate the root mean square speed, v_{rms}, of helium atoms at 300 K. At what temperature will oxygen molecules have the same value of v_{rms} ? 5

Take $m_{He} = 6{\cdot}67 \times 10^{-27}$ kg and $k_B = 1{\cdot}38 \times 10^{-23}$ J K^{-1}.