[This question paper contains 2 printed pages.]

Name of the course: B.Sc. (Prog.) Physical Science – NEP- UGCF

Semester: III

Name of the Paper: Heat and Thermodynamics

Unique Paper Code: 2222512301

Duration: 2 Hours

Maximum Marks: 60

Instructions for candidates

1. Write your Roll No. on the top immediately on the receipt of this question paper.
2. Attempt **four** questions in all.
3. Question No. **1** is compulsory.
4. All questions carry equal marks.
5. Use of non-programmable scientific calculator is allowed.

Q1. Attempt any ***five*** from the following: (5x3=15)

(a) Derive an expression for work done by an ideal gas during an isothermal expansion process.

(b) Using first law of thermodynamics, prove:

$$\frac{E_S}{E_T} = \frac{C_P}{C_V} = \gamma$$

where E_S & E_T are adiabatic and isothermal elasticity respectively.

(c) An investor claims to have developed an engine working between 500 K and 250 K with efficiency 54%. Is his claim valid? Justify.

(d) The average kinetic energy of a gas molecule at certain temperature is 6.21×10^{-21} J. Find the temperature.

(e) From Wien's displacement law calculate the temperature of sun, given that λ_m = 4753 Å and Wien's constant b = 0.2898×10^{-2} m-K.

(f) Define microstate and macrostate for a thermodynamical system.

Q2. (a) Using first law of thermodynamics, prove

$$C_P - C_V = \left[\left(\frac{\partial U}{\partial V}\right)_T + P\right]\left(\frac{\partial V}{\partial T}\right)_P$$

Hence show that for 1 mole of an ideal gas

$$C_P - C_V = R.$$

(b) Derive the equation of state for an ideal gas undergoing an adiabatic process in terms of pressure and volume.

(c) Draw the PV diagram for a Carnot's Engine and explain. Calculate the net work done by a Carnot engine in one complete cycle. Also derive an expression for its efficiency.

(4,4,7)

Q3. (a) Write the expressions for four thermodynamic potentials - Internal Energy (U), Helmholtz function (F), Enthalpy (H) and Gibb's function (G). Derive four Maxwell's thermodynamical relations using these thermodynamic potentials.

(b) Given W = (U- G)/T where G is Gibb's function and U the internal energy. Show that W is constant for an ideal gas undergoing an adiabatic process.

(c) 50 g of water at 0°C is mixed with an equal mass of water at 100°C. Calculate the resultant increase in entropy. Given: specific heat of water is 1 cal g^{-1} $°C^{-1}$.

(9,3,3)

Q4. (a) Derive an expression for mean free path for molecules in a gas using zeroth order approximation.

(b) Using kinetic theory of gases, obtain an expression for viscosity η of a gas and discuss its variation with temperature and pressure.

(c) What do you understand by a black body? Calculate the energy radiated by a black body at a temperature of 200 K. Given Stefan's constant = 5.67x 10^{-8} $MT^{-3}K^{-4}$ in SI units.

(4,6,5)

Q5. (a) Derive Plank's law of black body radiation.

(b) Compare the basic postulates of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

(c) Deduce relationship between Entropy and thermodynamic probability. (6,4,5)

Values of Constants:

Boltzmann's constant, $k = 1.38 \times 10^{-23} JK^{-1}$

Universal gas constant, $R = 8.31 Jmol^{-1}K^{-1}$

(3000)