Name of the Department: Physics

Name of the Course: B.Sc. Hons. Physics - CBCS_Core

Name of the Paper: Thermal Physics

Semester: III

Unique Paper Code: 32221302

Question paper Set number: B

Duration: 3 Hours **Maximum Marks: 75**

Instructions for Candidates

1. Answer any four questions.
2. All Questions carry equal marks.

Q. 1 Explain the terms open system, closed system and isolated system. What is meant by an equation of state of a thermodynamic system?

Starting with V = V (p, T) and using the condition for an exact differential, prove that

$$\left(\frac{\partial \beta_T}{\partial T}\right)_p = -\left(\frac{\partial \alpha}{\partial p}\right)_T$$

where β_T is the isothermal compressibility and α is coefficient of volume expansion.

Using the first law of thermodynamics and the equation of state for an ideal gas calculate the fraction of the heat supplied available for external work if a diatomic ideal gas near room temperature is expanded at constant pressure and at constant temperature.

Q. 2 mention the significance of the Second Law of Thermodynamics.

Draw a labelled PV diagram and the corresponding TS diagram for a Carnot engine and explain its working. Hence, obtain an expression for its efficiency.

If 20 kJ are added to a Carnot cycle at a temperature of 100°C and 14.6 kJ are rejected at 0°C, determine the location of absolute zero on the Celsius scale.

Q. 3 Prove that the slope on a TS diagram of an isochoric curve is T/C_V and that of an isobaric curve is T/C_p.

1 kg of ice at - 5°C is exposed to the atmosphere which is at 20°C. The ice melts and attains thermal equilibrium with the atmosphere. Determine the entropy increase of ice. Given that C_p of ice is 2.093 kJ/kg-K and the latent heat of fusion of ice is 333.3 kJ/kg.

State Nernst-Simon Statement of the Third Law of Thermodynamics. Use it to prove that the volume expansion coefficient at constant pressure as well as the pressure expansion coefficient at constant volume vanish as T approaches 0 K.

Q. 4 Find the diffusion coefficient of hydrogen at STP if the free path of the molecule is 1.6×10^{-7}m.

Using Maxwell's thermodynamic relations, show that the ratio of adiabatic to isobaric volume expansivity is **$1/(1-\gamma)$**.

Discuss the principle of magnetic cooling by adiabatic demagnetisation. State the limitations of the method.

Q. 5 Depict graphically the Maxwell-Boltzmann law of distribution of molecular velocities of an ideal gas for two different temperatures. Discuss the salient features of the curves.

The melting point of lead under normal pressure is 600 K. What will be the change in its value when pressure is increased to 100 atm. The density of lead in solid and liquid phases is 11.01 g cm^{-3} and 10.65 g cm^{-3}, respectively. The latent heat of fusion is 24.5×10^7 erg g^{-1}.

A cathode-ray tube is working such that 90% of the electrons leaving the cathode reach the anode 20 cm away without making a collision. The diameter of an ion is 3.6×10^{-10} m and the electron temperature is 2000 K. Calculate the pressure inside the tube. Use the electronic mean free path $4/\sigma n$, where σ is the cross-section of the ion.

Q. 6 Write the van der Waal's equation of state for n moles of a real gas. What were the modifications introduced in the properties of an ideal gas to obtain this equation and what do the terms involving the constants in this equation represent?

Compare the isotherms for CO_2 obtained experimentally by Andrews with the theoretical isotherms of van der Waal.

Show that in Joule-Thomson expansion process the enthalpy remains constant. Calculate the drop in temperature produced by the adiabatic throttling process in the case of oxygen when the pressure is reduced by 50 atm. and the initial temperature of the gas is 27℃. Given that the van der Waal's constants
$a = 1.32 \times 10^{12} cm^4 dynes\, mol^{-2}, b = 31.2 cm^3 mol^{-1}$ and $C_p = 7 cal\, mol^{-1} K^{-1}$.