[This question paper contains 2 printed pages.]

Your Roll No...............

K

Sr. No. of Question Paper : 5813

Unique Paper Code : 2222012302

Name of the Paper : Thermal Physics

Name of the Course : **B.Sc. Hons.– (Physics)_NEP: UGCF-2022**

Semester : III

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question no. **1** is compulsory. Attempt any **five** questions including Question no. **1**. **All** questions carry equal marks. (Use of non-programmable scientific calculator is allowed)

Q 1. Attempt any six questions. (3x6)

a) Explain what you understand by the adiabatic lapse rate.

b) If the door of a refrigerator is kept open for a long time, will it make the room cooler or warmer? Support your answer.

c) Determine the change in entropy when a mole of an ideal gas undergoes free expansion in which its volume changes to four times the original volume.

d) What is Gibb's free energy? Give its significance.

e) Prove that $U = F - T\left(\frac{\partial F}{\partial T}\right)_V$; where all symbols have their usual meanings.

f) Show that the mean energy of a Maxwellian gas molecule is three times its most probable energy.

g) Calculate the critical temperature of helium if the critical pressure is 2.26 atm and critical density is 69 kg m^{-3}.

h) Explain whether the free adiabatic expansion of a perfect gas leads to cooling or heating. Justify your answer.

Q 2. a) State first law of thermodynamics. Give the significance and limitation of the law. (5)

b) Derive a relation between the pressure and volume of a perfect gas undergoing an adiabatic change of state. Show that the adiabatic elasticity of a perfect gas is γ times its isothermal elasticity. (9)

c) Prove that $dH = C_P dT + V(1-\beta T)dP$; where β is the volume expansivity and other symbols have their usual meanings. (4)

Q 3. a) State and prove Carnot's theorem. (6)

b) Define thermodynamic scale of temperature. Show how it is identical with the perfect gas temperature. Explain why negative temperature is not possible on this scale. (6)

c) A reversible heat engine converts one-sixth of the input heat into work. When the temperature of the sink is reduced by 62°C, its efficiency is doubled, calculate the temperature of the source and the sink. (6)

Q 4. a) Explain Clausius statement of the second law of thermodynamics. Obtain the expression of the change in entropy in terms of the heat flow during an irreversible process. (8)

b) Will the entropy increase or decrease when 50 g of water at 0°C is mixed with 100 g of water at 80°C? Determine the change in the entropy. (4)

c) Describe how a magnetic substance is cooled to very low temperature by adiabatic demagnetization. (6)

Q 5. a) Describe how the second order phase transition is different from the first order phase transition. Give a reason why the Clausius Clapeyron equation fails at the transition point. Hence derive the Ehrenfest equation. (8)

b) Using Maxwell's relation, prove

i. $TdS = C_P dT - \boldsymbol{TV\beta dP}$ and (7)

ii. $\gamma - 1 = \frac{TV\beta^2}{\kappa_T C_V}$; where β is the volume expansivity and κ_T is the isothermal compressibility and other symbols have their usual meanings.

c) A substance on melting increases its specific volume by 0.150 $cm^3\ g^{-1}$. Determine the change in the melting point if the pressure is increased by two atmospheres. Given: Melting point of the substance = 80°C and its latent heat of fusion = 36 cal g^{-1}. (3)

Q 6. a) Derive an expression for the mean free path and discuss its dependence on temperature and pressure. (9)

b) Deduce the expressions for average velocity, root mean square velocity and most probable velocity of a gas molecule in terms of temperature (T) and Boltzmann constant (k_B) using the Maxwell Boltzmann Law of distribution of molecular velocities. (9)

Q 7. a) Describe the Joule-Thomson porous-plug experiment and discuss the results. Hence obtain the expression for Joule-Thomson coefficient. (12)

b) Calculate the drop in temperature when carbon dioxide gas suffers Joule-Thomson expansion at 30°C. The pressures on the two sides of the porous plug are given as 40 atm and 1 atm respectively. The van der Waals' constants of the gas are a = 36.5 x 10^{-2} Nm^4mol^{-2}, b=5.28 x 10^{-5} m^3mol^{-1} (C_P = 36.57 $Jmol^{-1}K^{-1}$ and R = 8.31 $Jmol^{-1}K^{-1}$). (6)

(1500)