Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, May 2025

Course : THERMAL PHYSICS **Semester : II**
Program : BSc PHYSICS BY RESEARCH **Time : 03 hrs.**
Course Code: PHYS1033 **Max. Marks: 100**

Instructions:

- **All questions are compulsory (Q9 and Q11 have an internal choice).**
- **Use of scientific calculator is allowed.**

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the following formulations of the second law of thermodynamics: (a) Kelvin Plank statement (b) Clausius statement	**2** **2**	**CO1**
Q 2	Derive the expressions for specific heats at constant volume (C_V) and constant pressure (C_P), and hence obtain the relation: $$C_P - C_V = R$$ Where symbols have their usual meanings.	**4**	**CO1**
Q 3	Starting from the definition of a second-order phase transition, derive the Ehrenfest relation: $$\frac{dP}{dT} = \frac{CP_2 - CP_1}{VT(\alpha_2 - \alpha_1)}$$ Where symbols have their usual meanings.	**4**	**CO1**
Q 4	Explain the construction and working of the apparatus used to achieve low temperatures based on the principle of Adiabatic Demagnetization.	**4**	**CO2**

Q 5	(a) Explain Boyle temperature. (b) Show that the relation between the Boyle temperature "T_B" and the critical temperature "T_C" is given by: $$T_B = 3.38\ T_C$$	**2** **2**	**CO2**
SECTION B **(4Qx10M= 40 Marks)**			
Q 6	In the Van der Waals equation below, derive the expression for the volume correction term (b): $$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$ Where symbols have their usual meanings.	**10**	**CO1**
Q 7	Calculate the increase in entropy when 50 grams of ice at -10 ^oC are converted into steam at 100 ^oC. Given that: Specific heat of ice = 2090 J Kg^{-1} K^{-1}, Specific heat of water = 4180 J Kg^{-1} K^{-1}, Latent heat of ice = 3.35×10^5 J Kg^{-1}, and Latent heat of steam = 2.26×10^6 J Kg^{-1}	**10**	**CO2**
Q 8	Derive the following Maxwell's first and second thermodynamical relations: (a) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$ (b) $\left(\frac{\partial T}{\partial P}\right)_S = +\left(\frac{\partial V}{\partial S}\right)_P$	**5** **5**	**CO3**
Q 9	Explain the porous-plug experimental setup for the production of low temperature.	**10**	**CO4**

	OR Derive the expression of the Joule Thomson coefficient "μ" for a Van der Waals gas and hence obtain the expression of the temperature of inversion $\left(T_i = \frac{2a}{bR}\right)$. Where symbols have their usual meanings.		
	SECTION-C **(2Qx20M=40 Marks)**		
Q 10	(a) Explain "Thermodynamic Scale of Temperature" (b) Find the mean free path, frequency of collision and molecular diameter of a gas, given the viscosity of gas $\eta = 160 \times 10^{-7}$ N m^{-2} per unit velocity gradient, average velocity $\bar{c} = 4.2 \times 10^{2}$ ms^{-1}, density $\rho = 1.25$ kg m^{-3} and number of molecules per $m^3 = 3.5 \times 10^{25}$.	**5** **15**	**CO3**
Q 11	Explain the construction and working of Andrews' experiment to study real gas behavior. Illustrate and explain the isothermals from Andrews' experiment at 13.1 ^oC, 21.5 ^oC, 31.1 ^oC, 35.5 ^oC and 48.1 ^oC. Depict and describe the 'border curve' and the 'critical point'. **OR** Derive the following Clausius inequality considering a heat engine sandwiched between two refrigerators and all three operating between multiple heat reservoirs: $$\oint \frac{\delta H}{T} \leq 0$$ And explain its physical significance.	**20**	**CO4**