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

UPES

End Semester Examination, May 2025

Course: Thermodynamics **Semester: 1V**

Program: BSc Geology/BSc Maths by Research **Time : 03 hrs.**

Course Code: MECH2020 **Max. Marks: 100**

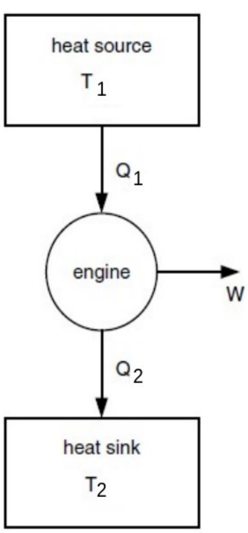
Instructions: All questions are mandatory in Section A.
Internal choices are given in questions 9 and 11 of Sections B and C respectively.
Calculator is allowed.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q1	Given that 1 mole of helium gas at an absolute temperature of 6K occupies a volume of 2 x 10^{-5} m^3, calculate the <u>difference</u> between its specific heat at constant pressure (C_P) and specific heat at constant volume (C_V). Additionally, demonstrate that the gas cannot be considered an ideal gas. Given: Isobaric Expansivity (α) = 5.3 x 10^{-2} K^{-1} Isothermal Compressibility (β) =9x10^{-8} m^2/N	**4**	**CO2**
Q2	What is Brownian motion, and how does it provide evidence for the existence of atoms and molecules?	**4**	**CO2**
Q3	What is meant by the pressure of a gas? How is pressure exerted by a gas on the walls of its container?	**4**	**CO2**
Q4	Using the principles of Kinetic Theory of Gases, compute the average kinetic energy of: **(A)** a He gas molecule, **(B)** an O_2 gas molecule, at Temperature 300K. Given $k_B = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}	**2** **2**	**CO2**
Q5	A cold glass of water is kept in a room in the summers. In which direction will heat transfer, glass to room or room to glass? Justify your answer. Which law of thermodynamics will govern the direction of heat transfer?	**4**	**CO2**

SECTION B
(4Qx10M= 40 Marks)

Q6	**(A)** Discuss the importance of the Clausius-Clapeyron equation relating it to the phase diagram of water. **(B)** Explain why the boiling point of water reduces as we go from sea level to mountains.	**7** **3**	**CO4**

Q7	**(A)** What do you understand by degrees of freedom of a gas molecule. What is the degree of freedom of a (i) monoatomic, (ii) diatomic and (iii) polyatomic gas molecule? **(B)** State the principle of Equipartition of energy and discuss how it corrected the predictions of Specific heat of Diatomic and Polyatomic gases.	**4** **6**	**CO4**
Q8	**(A)** Describe the Van der Waals gas equation and explain how it is different from the ideal gas equation. **(B)** List the assumptions of the kinetic theory of gases that Van der Waals had to modify to derive his equations.	**6** **4**	**CO3**
Q9	How do we define Enthalpy (H) of a thermodynamic system? Derive the 2^{nd} Maxwell's relation starting with the state function H and taking S (entropy) and P (pressure) as the natural variables. **OR** **(A)** If mass of one perfume gas molecule is 10^{-25}Kg, compute the root mean square speed of smoke molecules at room temperature. Given $k_B = 1.38 \times 10^{-23}\ m^2\ kg\ s^{-2}\ K^{-1}$ **(B)** As computed in part (A), if the velocity of gas molecules are so high, then why do you think a perfume bottle opened in one corner of a room takes considerable time to diffuse across a room? How did Clausius resolve this paradox?	**10** **4** **6**	**CO3** **CO3**
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	Consider the Carnot Heat Engine shown in the Figure and answer the following questions:  **(A)** Calculate the efficiency of the Engine if Q_1 = 400J, Q_2 = 350J. Suggest some ways to increase the efficiency of the engine? **(B)** If Q_1 = 400J, Q_2 = 350J, T_1 = 100 ^{0}C, T_2= 0 ^{0}C, calculate the total change in Entropy of the composite system. **(C)** Can we construct a heat engine with Q_1 = 400J, Q2=350J, T_1 = 100 ^{0}C, T_2= 60^{0}C? Give a reason for your answer. **(D)** Consider two Carnot engines joined in series;	**5** **5** **5** **5**	**CO3**

	Engine-1 works between 200 ^{0}C and 100 ^{0}C and Engine-2 works between 100 ^{0}C and 0 ^{0}C . Draw the composite system and compute the efficiency of the composite Engine (Engine1+Engine2).		
Q11	**(A)** Derive the mathematical form of the Maxwell–Boltzmann distribution of molecular speeds and describe its implications. **(B)** Why does the Maxwell–Boltzmann distribution function for a particular gas become flatter for higher temperatures? **OR** **(A)** Derive an expression for the mean free path of an ideal gas in terms of the diameter of the gas molecules. **(B)** Hydrogen molecules of radius 1.37 x 10^{-10} m moves with speed 1840 m/s. Calculate the (i) Collision frequency (number of collisions per second) (ii) Mean free path	**15** **5** **15** **5**	**CO4** **CO4**