Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – SUMMER 2024

Subject Code:3130507 Date:29-06-2024

Subject Name: Chemical Engineering Thermodynamics I

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define equilibrium and state Phase rule	**03**
	(b)	Explain (i) System and Surroundings (ii) Macroscopic and Microscopic aspect	**04**
	(c)	Derive the first law of thermodynamics for close system	**07**
Q.2	**(a)**	Show that C_P - C_V = R for an ideal gas	**03**
	(b)	Write a note on various statements of the second law of thermodynamics	**04**
	(c)	A steel casting weighing 35 kg at a temperature 725K is quenched in 150 kg oil at 275K. If there are no heat losses, Calculate the change in entropy. The specific heat (C_P) of steel is 0.88 kJ/kg K and that of oil is 2.5 kJ/kg K.	**07**
		OR	
	(c)	For an ideal gas with constant heat capacities, undergoing a reversible adiabatic (and therefore isentropic) process, prove that: $$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$	**07**
Q.3	**(a)**	Explain Hess law of heat summation	**03**
	(b)	A system consisting of a gas confined in a cylinder undergoes following series of processes before it is brought back to initial conditions. Step1: A constant pressure process when it receives 500J of work and gives up 200J of heat. Step2: A constant volume process when it receives 100J of heat. Step3: An adiabatic process. Determine the change in internal energy ΔU during each step and work done during adiabatic process.	**04**
	(c)	Calculate the compressibility factor and molar volume of methanol vapour at 500K and 10bar. Using virial equation truncated up-to the third virial coefficient? B = -2.19×10^{-4} m^3/mol, C -1.73×10^{-8} m^6/mol^2.	**07**
		OR	

Q.3 **(a)** Write a note on Third law of thermodynamics **03**

(b) Explain the operation of heat pump. **04**

(c) For the following reaction, **07**

$$CO_2 + 4H_2 \longrightarrow 2H_2O + CH_4$$

The standard heat of reaction at 298 K is -164.987 kJ.

The constants in the heat capacity (J/mol K) are as below;

	α	$\beta \times 10^3$	$\gamma \times 10^6$
CO_2	26.75	42.26	-14.25
H_2	26.88	4.35	-0.33
H_2O	29.16	14.49	-2.02
CH_4	13.41	77.03	-18.74

Calculate the standard heat of reaction at 773K. Use $C_p = \alpha + \beta T + \gamma T^2$

Q.4 **(a)** A heat engine operates between a heat source at 700 K and a heat sink at 300 K. What is the maximum efficiency of the engine? **03**

(b) Enlist various liquefaction processes and explain any one process used in the process industry **04**

(c) Show that in a 2-stage reciprocating compressor, the min. total work results when the pressure ratios in each stage are equal and are given by the square root of the over-all pressure ratio **07**

OR

Q.4 **(a)** Write Short note on "Ejectors". **03**

(b) What is an equation of state? Give the expression for any three equations of state **04**

(c) Explain with a schematic diagram the working of an absorption refrigeration system **07**

Q.5 **(a)** Discuss about Pitzer's modification to law of corresponding states? **03**

(b) List the properties affecting the choice of a refrigerant? **04**

(c) Explain the operation of heat pump. **07**

OR

Q.5 **(a)** Draw and explain the mnemonic diagram for the thermodynamics property relations. **03**

(b) List all Maxwell relations **04**

(c) Show that in multistage compression for minimum work, the inter-stage pressure is the geometric mean of the initial and final pressures **07**

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