Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–III EXAMINATION – WINTER 2025

Subject Code:3130507 Date:15-12-2025

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.**

Q.1	**(a)**	The potential energy of a body of mass 10 kg is 1.5 kJ. What is the height of the body from the ground?	**03**
	(b)	Define intensive properties and extensive properties. State whether these properties are intensive or extensive: pressure, temperature, volume, specific volume, and density.	**04**
	(c)	With a neat sketch, explain the PVT behavior of pure substance using PT and PV diagrams.	**07**
Q.2	**(a)**	Explain procedure to calculate compressibility factor (z) using Pitzer correlations for the compressibility factor.	**03**
	(b)	Explain three-parameter theorem of corresponding states.	**04**
	(c)	Water at 368 K is pumped from a storage tank at the rate of 25 m^3/h. The motor for the pump supplies work at the rate of 2 hp. The water passes through a heat exchanger, where it gives up heat at the rate of 42000 kJ/min and is delivered to a second storage tank at an elevation of 20 m above the first tank. Calculate the temperature of the water delivered to the second storage tank? Assume that the enthalpy of water is zero at 273 K and the specific heat of water is constant at 4.2 kJ/kg K.	**07**
		OR	
	(c)	Derive energy balance equation for steady state flow process.	**07**
Q.3	**(a)**	An ideal gas is heated in a closed system at a constant volume from 300 K and 1 bar to a pressure of 2 bar in a reversible process. Determine the heat and work effects. Assume C_P = 29.3 kJ/kmol K.	**03**
	(b)	Given that latent heat of vaporization of water at 100°C is 2257 J g^{-1}, estimate latent heat at 300°C using Watson equation. Critical temperature for water, T_C =647.1 K	**04**
	(c)	For van der Waals equation of state prove that $a = \frac{27}{64}\frac{R^2T_C^2}{P_C}$, $b = \frac{1}{8}\frac{RT_C}{P_C}$	**07**
		OR	
Q.3	**(a)**	Determine the change in entropy when 2 kg of a gas at 277 K is heated at constant volume to a temperature of 368 K. Take the specific heat at constant volume = 1.42 kJ/kg K.	**03**
	(b)	With neat sketch explain: (1) Pressure-Enthalpy diagram, and (2) Mollier diagram.	**04**
	(c)	Explain Mnemonic diagram for thermodynamic property relation. Write down fundamental property relations and Maxwell equations for homogeneous fluid of constant composition using Mnemonic diagram.	**07**

Q.4 **(a)** Explain Hess's law of constant heat summation. **03**

(b) From a reservoir at 600 K, 1000 J of heat is transferred to an engine that operates on the Carnot cycle. The engine rejects heat to a reservoir at 300 K. Determine the thermal efficiency of the cycle and the work done by the engine. **04**

(c) Define standard heat of reaction and standard heat of combustion. Calculate the standard heat of combustion of n-pentane gas at 298.15 K (25°C) if the combustion products are $H_20(l)$ and $CO_2(g)$? For n-C_5H_{12}, $H_2O_{(l)}$ and $CO_{2(g)}$ values of ΔH^o_{f298} are -146760, -285830 and -393509 J/mol respectively. **07**

OR

Q.4 **(a)** State general statements for the second law of thermodynamics. **03**

(b) Calculate the heat of formation of chloroform ($CHCl_3$) with the following given data: **04**

(a) $CHCl_3(g)+\frac{1}{2}O_2(g)+H_2O(l) \rightarrow CO_2(g)+3HCL(g)$; ΔH^0_{298}=-509.93 kJ

(b) $H_2(g)+\frac{1}{2}O_2(g) \rightarrow H_2O(l)$; ΔH^0_{298}=-296.03 kJ

(c) $C(s)+O_2(g) \rightarrow CO_2(g)$; ΔH^0_{298}=-393.78 kJ

(d) $\frac{1}{2}H_2(g)+\frac{1}{2}Cl_2(g) \rightarrow HCl$; ΔH^0_{298}=-167.57 kJ

(c) Explain PV and TS diagram showing Carnot cycle for ideal gas. **07**

Q.5 **(a)** Write a short not on residual properties. **03**

(b) With H-S diagram explain adiabatic compression process. **04**

(c) Water flowing upward through a vertical pipe enters a reducer with a velocity of 1 m s^{-1}. The diameters at the entrance and exit of the reducer are 0.2 m and 0.1 m respectively. If the pressure at the entrance to the section is 105 kPa, what is the pressure at the exit given that the entrance and exit are 5 m apart? **07**

OR

Q.5 **(a)** Determine the increase in entropy of solid magnesium when the temperature is increased from 300 K to 800 K at atmospheric pressure. The heat capacity is given by the following relation: **03**
$C_P = 26.04 + 5.586 \times 10^{-3} T + 28.476 \times 10^4 T^{-2}$
where C_P is in J mol^{-1} K^{-1} and temperature in K.

(b) Derive an equation for the Coefficient of performance (ω) of Carnot refrigeration cycle. **04**

(c) With neat diagram explain Claude liquefaction process. **07**

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