Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III(NEW) EXAMINATION – WINTER 2022

Subject Code:3130507 Date:24-02-2023

Subject Name:Chemical Engineering Thermodynamics I

Time:02:30 PM TO 05:00 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)**	What is the scope and limitations of thermodynamics?	**03**
	(b)	Explain (i) System and Surroundings (ii) Macroscopic and Microscopic aspect	**04**
	(c)	Derive the first law of thermodynamics for open system	**07**
Q.2	**(a)**	Explain compressibility factor	**03**
	(b)	Derive van der Waal's equation of state	**04**
	(c)	Determine the molar volume of gaseous methane at 300 K and 600 bar by the following methods: (a) Using the ideal gas equation (b) Using the van der Waals equation given that a = 0.2285 N m^4/mol^2; b = 4.27 x 10^{-5} m^3/mol	**07**
		OR	
	(c)	A steel casting at a temperature 725 K and weighing 35 kg is quenched in 150 kg oil at 275 K. If there are no heat losses, determine 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**
Q.3	**(a)**	What is an adiabatic process? Write the expression for work done during reversible adiabatic process	**03**
	(b)	Explain the terms 'state function' and 'path function'	**04**
	(c)	The *P-V-T* behaviour of nitrogen is represented by the ideal gas equation $PV = nRT$, where n is the number of moles of the gas and R the ideal gas constant (R = 8.314 kJ/kmol K). The heat capacities of the gas are C_V = 20.8 and C_P = 29.1 kJ/kmol K. The gas initially at 15 bar and 280 K is undergoing a change of state to the final condition of 1.5bar and 340 K. Determine the change in internal energy and the change in enthalpy.	**07**
		OR	
Q.3	**(a)**	Explain Hess law of heat summation	**03**
	(b)	What is an equation of state? Give the expression for any three equations of state	**04**
	(c)	Three moles hydrogen and 1 mol nitrogen, both at 10 bar and 373K are separately admitted, mixed and then heated to 773 K in a heat exchanger with a corresponding increase in pressure. Calculate the entropy change in the process. Assume C_V = 21 J/mol K for the mixture.	**07**

Q.4	**(a)**	Define 1. Entropy. 2. Third law of thermodynamics 3. One ton of refrigeration	**03**
	(b)	An ideal gas with heat capacity C_P = 29.7 kJ/kmol K flows steadily through a long capillary tube at 5 bar and 350 K and leaves at 2 bar. What is its exit temperature?	**04**
	(c)	Derive Maxwell Relations	**07**

OR

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)	State various liquefaction processes and explain any one	**04**
	(c)	Derive an expression of entropy change involving ideal gas for following process? 1) Constant volume process. 2) Constant pressure process. 3) Isothermal process. Also find the change in entropy when 2 kg of a gas at 277K is heated at constant volume to a temperature of 368K. Given C_V = 1.42 kJ/kg·K.	**07**
Q.5	**(a)**	Air expands through a nozzle from a negligible initial velocity to a final velocity of 350 m/s. What is the temperature drop of air, if air is assumed an ideal gas with $C_P = (7/2)R$?	**03**
	(b)	Explain vapor-compression refrigeration cycle?	**04**
	(c)	Explain with a schematic diagram the working of an absorption refrigeration system	**07**

OR

Q.5	**(a)**	What is Joule-Thomson effect	**03**
	(b)	A refrigeration machine operating at a condenser temperature of 290 K needs 1.5 kW of power per ton of refrigeration. Determine the following: (i) The coefficient of performance (ii The heat rejected to the condenser	**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**