Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III(NEW) EXAMINATION – SUMMER 2023

Subject Code:3130507 Date:28-07-2023

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)**	Show that $C_P - C_V = R$ for an ideal gas.	**03**
	(b)	Discuss the state and properties of thermodynamics system.	**04**
	(c)	It is desired to compress isothermally one kmol of ammonia from initial state of 30 m^3 / kmol and 300 K to final state of 5 m^3 / kmol. It is known that the ammonia obey the relation as given below. $\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad \text{and} \quad dU = C_v\, dT + \frac{a}{V^2} dV$ where a = 423.3 kPa / $(m^3/kmol)^2$, b = 0.0373 m^3 / kmol, R = 8.314 kJ/kmol K. Calculate heat and work interaction with compression process.	**07**
Q.2	**(a)**	Explain the various limiting conditions satisfied by equation of state.	**03**
	(b)	Write short note on virial equation of state.	**04**
	(c)	Calculate the molar volume of ammonia at 373 K and 10 bar using (i) The van der Waals equation; given that, a = 4.225 lit^2 bar/mol^2 and b = 0.0371 lit/mol. (ii) The Redlich – Kwong equation; given that, the critical temperature is 405.5 K and the critical pressure is 112.8 bar for ammonia.	**07**
		OR	
	(c)	A mass of 500 gm of gaseous ammonia is contained in a 30,000 cm^3 vessel immersed in a constant temperature bath at 65 ^oC. Calculate the pressure of gas by each of the following. (i) The ideal gas equation (ii) The Redlich – Kwong equation (iii) The generalized virial coefficient correlation. Take: T_C = 405.7 K, P_C = 112.8 bar and ω = 0.253	**07**
Q.3	**(a)**	How is the Hess's law of constant heat summation useful in thermochemical calculations?	**03**
	(b)	What is the adiabatic flame temperature? How is it estimated? What influence does excess air have on its value?	**04**
	(c)	Oil at 500 K is to be cooled at a rate of 5000 kg/h in a counter-current exchanger using cold water available at 295 K. A temperature approach of 10 K is to be maintained at both ends of the exchanger.	**07**

The specific heats of oil and water are 3.2 kJ/kg K and 4.2 kJ/kg K respectively. Determine the total entropy change in the process.

OR

Q.3 **(a)** Write Kelvin – Planck and Clausius statements. **03**

(b) A steel casting (C_P = 0.88 kJ/kg K) at a temperature 725 K and weighing 35 kg is quenched in oil (C_P = 2.50 kJ/kg K) at 275 K. If there are no heat losses and final temperature achieved by casting and oil is 300 K. Calculate the mass of oil. **04**

(c) Discuss effect of temperature on standard heat of reaction. **07**

Q.4 **(a)** What is the change in entropy when 1- kmol of an ideal gas at 335 K and 10 bar is expanded irreversibly to 300 K and 1 bar? Take C_P = 29.3 kJ/kmol K. **03**

(b) Differentiate between reference properties, energy properties, and derived properties. **04**

(c) How would you obtain the Clapeyron equation from Maxwell's equations? What are the assumptions involved in the derivation of Clausius – Clapeyron equation from the Clapeyron equation? **07**

OR

Q.4 **(a)** The coefficient of compressibility and coefficient of volume expansion of mercury at 273 K and 1 bar are 3.9×10^{-6} $(bar)^{-1}$ and 1.8×10^{-4} K^{-1} respectively. Calculate Cv for mercury given that Cp = 0.14 kJ/kg K and density = 13.569×10^3 kg/m^3. **03**

(b) Calculate vapour pressure of water at 363 K, if the vapour pressure at 373 K is 101.3 kPa. The mean heat of vaporization in this temperature range is 2275 kJ/kg. **04**

(c) Discuss the different types of thermodynamic diagram with neat sketch and also, list their respective fields of application. **07**

Q.5 **(a)** Derive the equation of continuity for control volume. **03**

(b) Discuss the construction and working of ejector. **04**

(c) Discuss vapor compression cycle with neat sketch. **07**

OR

Q.5 **(a)** What are the desirable properties of a refrigerant? **03**

(b) Explain the working principle of a heat pump. **04**

(c) The maximum velocity attainable for isentropic flow of fluid in a uniform cross section pipe is equal to speed of sound in the fluid. **07**

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