Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3130507 Date:18-01-2024

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)**	State and explain the zeroth law of thermodynamics.	**03**
	(b)	Write a short note on phase rule.	**04**
	(c)	An ideal gas is compressed adiabatically from 1.5 bar, 338 K to 9 bar. The process is reversible and γ = 1.23 is constant over the entire range of conditions. Calculate (i) the temperature at the end of compression (ii) the work of compression (iii) the change in internal energy and change in enthalpy.	**07**
Q.2	**(a)**	Discuss Redlich – Kwong – Soave equation of state.	**03**
	(b)	Explain the principle of corresponding states and discuss the generalized compressibility chart.	**04**
	(c)	Calculate the pressure developed by 1-kmol gaseous ammonia contained in a vessel of 0.6-m^3 capacity at a constant temperature of 473 K by (i) the ideal gas equation. (ii) van der Waals equation of state; given that, a = 0.4233 N m^4/mol^2 and b = 3.73 x 10^{-5} m^3/mol (iii) Redlich – Kwong equation; given that, P_C = 112.8 bar and T_C = 405.5 K for ammonia.	**07**
		OR	
	(c)	Determine the van der Waals constants and the molar volume of ethane at the critical point, given that the critical temperature and pressure of ethane are 305.2 K and 49.4 bar respectively.	**07**
Q.3	**(a)**	Define: (a) standard heat of reaction (b) standard heat of formation (c) standard heat of combustion.	**03**
	(b)	What is the adiabatic flame temperature? How is it estimated? What influence does excess air have on its value?	**04**
	(c)	A block of copper at a temperature of 825 K and weighing 5-kg is dropped into 50-kg water at 300 K. If there are no heat losses what is the change in entropy of (a) copper (b) water and (c) copper and water both considered together? The constant pressure heat capacity of copper is 0.4 kJ/kg K and that of water is 4.2 kJ/kg K.	**07**
		OR	

Q.3 **(a)** Explain in brief: Clausius inequality. **03**

(b) Explain concept of entropy in brief. **04**

(c) Heat is transferred to 10 kg of air which is initially at 100 kPa and 300 K until its temperature reaches 600 K. Determine the change in internal energy, change in enthalpy, heat supplied and work done in the (a) constant volume process and (b) constant pressure process. **07**

Assume that air is an ideal gas. Take C_P = 29.099 kJ/kmol K, C_V = 20.785 kJ/kmol K and molecular weight of air = 29.

Q.4 **(a)** Using Maxwell's equation prove that $dH = Cp\ dT + V(1 - \beta T)\ dP$ where β is volume expansivity. **03**

(b) Explain residual properties in brief. **04**

(c) Calculate the internal energy, enthalpy, entropy and free energy for one mole of nitrogen at 773 K and 100 bar assuming that nitrogen behaves as an ideal gas. The molal heat capacity of nitrogen at 1 bar is given as **07**

$$C_P = 27.3 + 4.2 \times 10^{-3} T$$

where T is in K and C_P is in J/mol K. Enthalpy of nitrogen is zero at 273 K and 1 bar. The entropy of nitrogen is 192.4 J/mol K at 298 K and 1 bar.

OR

Q.4 **(a)** Using partial derivatives of entropy with temperature, derive entropy – heat capacity relationships. **03**

(b) Mercury has a density of 13.69×10^3 kg/m^3 in the liquid state and 14.193×10^3 kg/m^3 in the solid state, both measured at the melting point of 234.33 K at 1 bar. If the heat of fusion of mercury is 9.7876 kJ/kg, what is the melting point of mercury at 10 bar? **04**

(c) Discuss the H – T and H – S diagram with neat sketch and also, list their respective fields of application. **07**

Q.5 **(a)** Explain the working principle of Linde liquefaction process in brief. **03**

(b) Write short note on throttling process. **04**

(c) Derive the relation between area and velocity for isentropic flow through nozzles. **07**

OR

Q.5 **(a)** Explain any three desirable properties of a refrigerant. **03**

(b) Draw the components diagram and T – S diagram for Carnot refrigeration cycle. **04**

(c) Write a Short note on Claude process for gas liquefaction with neat diagram. **07**

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