Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–IV (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2140502 **Date: 06/06/2017**

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.**

Q.1		**Short Questions**	**14**
	1	Define Equation of State.	**01**
	2	Mention third law of thermodynamics.	**01**
	3	Mention characteristics of ideal gas.	**01**
	4	Define Acentric factor.	**01**
	5	Define Standard heat of formation	**01**
	6	State Carnot theorem for heat engines.	**01**
	7	State degree of freedom at critical point.	**01**
	8	Define compressibility factor.	**01**
	9	What is an isolated system?	**01**
	10	Define path function.	**01**
	11	Define heat capacity.	**01**
	12	Define intensive property and give an example.	**01**
	13	State Phase rule for non-reacting system.	**01**
	14	What is Mollier diagram?	**01**
Q.2	**(a)**	Mention various statements of second law of thermodynamics.	**03**
	(b)	Explain concept of entropy in brief.	**04**
	(c)	Explain P-V-T behavior of a pure fluid with neat diagrams.	**07**
		OR	
	(c)	Derive Maxwell's equations using fundamental property relations for a homogeneous fluid of constant composition.	**07**
Q.3	**(a)**	State the first Law of thermodynamics. Also, Explain its limitations.	**03**
	(b)	Derive the expression for the first law of thermodynamics for non-flow process.	**04**
	(c)	An ideal gas initially at 1 bar and 298.15 K is compressed to 5 bar and 298.15 K by a two-step process: first isobaric cooling and then isochoric heating. Calculate ΔU, ΔH, Q, and W for each step considering that heat capacities are independent of temperature, C_V = 20.78 J/(mol K) and C_P = 29.10 J/(mol K). At 298.15 K and 1 bar, the molar volume of the gas is 0.02479 m^3/mol.	**07**

OR

Q.3 **(a)** Using Maxwell's equation prove that : **03**

$$dH = Cp\, dT + V(1 - \beta T)\, dP \qquad \text{where } \beta = \text{Volume expansivity}$$

(b) Define and explain the reversible process. Describe reversible expansion of a gas with necessary diagram. **04**

(c) Discuss about thermodynamic diagrams. **07**

Q.4 **(a)** State and explain "Two Parameter" theorem of generalized correlations for gases. **03**

(b) Discuss Virial equation of state in brief. **04**

(c) Calculate the standard heat of reaction of the methanol synthesis at 800 ^oC. **07**

$$CO_{(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(g)}.$$

Consider standard heat of reaction at 298.15 K is -90135 J.

$C_P/R = A+BT+CT^2+DT^{-2}$ and T is in K.

Gas	**A**	**B x 10^3**	**C x 10^6**	**D x 10^{-5}**
CH_3OH	2.211	12.216	-3.450	0.0
CO	3.376	0.557	0.0	-0.031
H_2	3.249	0.422	0.0	0.083

OR

Q.4 **(a)** Discuss any two different correlations to estimate latent heat of vaporization of pure substances. **03**

(b) Discuss Vander Waals equation of state in detail. **04**

(c) Reported values for the Virial coefficients of Isopropanol vapor at 200 ^oC are: **07**

$$B = -388\ cm^3 / mol \quad \text{and} \quad C = -26000\ cm^6 / mol^2.$$

Calculate V and Z for iso-proponal vapor at 200 ^oC and 10 bar by the following equations.

(i) Ideal gas equation (ii) $Z = 1 + (B/V) + (C/V^2)$

Q.5 **(a)** Define: sonic velocity, nozzle and Mach no. **03**

(b) Write a Short note on Ejector **04**

(c) Explain factors affecting choice of refrigerant with examples. **07**

OR

Q.5 **(a)** Differentiate between Heat pump and Heat engine **03**

(b) Write a short note on Claude process for gas liquefaction with neat diagram **04**

(c) Starting from energy balance equation and the continuity equation, Show that maximum velocity attained by a gas in steady – state adiabatic flow in a horizontal pipe of constant cross-sectional area is **07**

$$u_{max}^2 = -V^2 \left(\frac{\partial P}{\partial V} \right)_S$$

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