Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–III (NEW) EXAMINATION – WINTER 2021

Subject Code:3130507 Date:21-02-2022

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 Zeroth law and Third law of thermodynamics	**03**
	(b)	Discuss in brief about choice of refrigerant for refrigeration system.	**04**
	(c)	Explain vapour compression refrigerant cycle with neat flow diagram and T-S diagram.	**07**
Q.2	**(a)**	Discuss strength and limitations of thermodynamics in chemical engineering.	**03**
	(b)	Select whether the following properties are extensive or intensive: (a) temperature, (b) volume, (c) specific volume (d) heat capacity, (e) potential energy, (f) pressure (g) Internal energy (h) Enthalpy.	**04**
	(c)	Starting from fundamentals, Derive a mathematical expression of the first law of thermodynamics for a steady state flow process.	**07**
		OR	
	(c)	Using Maxwell's equation prove that : $dH = Cp\ dT + V(1 - \beta T)\ dP$ $dS = Cp\ dT/T - \beta V\ dP$. Where β = Volume expansivity.	**07**
Q.3	**(a)**	How many degrees of freedom have each of the following system? (1) Liquid water in equilibrium with its vapor. (2) Liquid water in equilibrium with a mixture of water vapor and nitrogen. (3) A liquid solution of alcohol in water in equilibrium with its vapor.	**03**
	(b)	From the First Principle $dU = dQ - dW$ prove the following $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$	**04**
	(c)	Discuss Cluasius Inequality in detail	**07**
		OR	
Q.3	**(a)**	Give answer with Justification: Two reversible heat engines are operated between absolute temperature T_1, T_2& T_3 as shown in **figure (i).** If the work done per cycle by two engine are same then the temperature T_2 must be: a. Arithmetic mean of T_1& T_3 b. Geometric mean of T_1& T_3 c. Logarithmic mean of T_1& T_3 d. Harmonic mean of T_1& T_3	**03**
	(b)	Explain concept of entropy in brief.	**04**
	(c)	Discuss the Thermodynamic temperature scale in detail	**07**
Q.4	**(a)**	Explain physical significance of Virial coefficients.	**03**
	(b)	Give significance of Compressibility factor and volume expansivity	**04**

(c) Discuss the PVT- behavior of pure liquids with PV and PT diagram for a pure material. **07**

OR

Q.4 **(a)** Explain the principle of corresponding states and discuss the generalized compressibility chart. **03**

(b) Define: i) standard heat of formation ii) standard heat of combustion iii) standard heat of reaction iv) latent heat **04**

(c) Calculate the volume occupied by one mole of oxygen at 300 K and 100 bar using **07**

(a) The ideal gas law

(b) The vad der waals equation.

a = 0.1378 N m^4/ mol^2 and b = 3.18×10^{-5} m^3/ mol

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

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

(c) The standard heat of reaction at 298K is -42.433 kJ for the reaction $C_2H_{4(g)} + H_2O_{(g)} \rightarrow C_2H_5OH_{(g)}$. Calculate the heat of reaction at 400 K. The constants in the heat capacity equation Cp = a + bT + cT2 are as given below: (C_P is in J/mol.K and T in K) **07**

Component	a	b	c
C_2H_4	11.85	119.75×10^{-3}	-36.53×10^{-6}
H_2O	30.38	9.62×10^{-3}	1.19×10^{-6}
C_2H_5OH	29.27	166.39×10^{-3}	-49.93×10^{-6}

OR

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

(b) Explain isenthalpic process in detail **04**

(c) Using Hess's law, calculate the heat of formation for chloroform ($CHCl_3$) with the following data: **07**

(a) $CHCl_{3(g)} + 0.5O_{2(g)} + H2O \rightarrow CO_{2(g)} + 3HCl_{(g)}$; ΔH^0 298 = -509.93 kJ

(b) $H_2(g) + 0.5O2_{(g)} \rightarrow H_2O_{(l)}$; ΔH^0 298 = -296.03 kJ

(c) $C_{(s)} + O2_{(g)} \rightarrow CO_{2(g)}$; ΔH^0 298 = -393.78 kJ

(d) $0.5H_{2(g)} + 0.5Cl_{2(g)} \rightarrow HCl_{(g)}$; ΔH^0 298 = -167.57 kJ

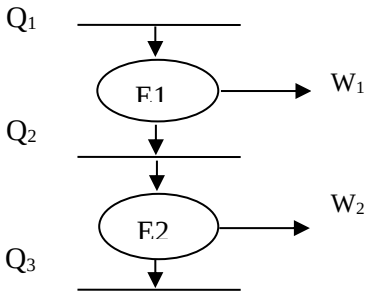

Figure (i)