

ROLL No:

--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Total number of pages:[2]

B.Tech. || CHE || 3rd Sem
Chemical Engg. Thermodynamics

Subject Code:BTCH-304A

Paper ID:

Time allowed: 3 Hrs

Max Marks: 60

Important Instructions:

- All questions are compulsory
- Assume any missing data
- Additional instructions, if any

PART A (10x2marks)

Q1. Short-Answer Questions:

- What are point and path properties? Explain with examples.
- What is law of corresponding states? Explain how this law is modified using Pitzer's modification.
- What is the effect of pressure on equilibrium constant?
- What do you mean by Helmholtz free energy & Gibb's energy.
- Define fugacity and fugacity coefficient?
- What do you mean by Joule Thomson Coefficient?
- What do you mean by partial properties? Give examples of partial molar properties.
- Define the terms Activity and Activity Coefficient.
- What is the significance of van Laar equation?

PART B (5x8marks)

Q. 2. One mole of an ideal gas with $C_p = (7/2)R$ and $C_v = (5/2)R$ expands from $P_1 = 8$ bar and $T_1 = 600K$ to $P_2 = 1$ bar by each of following paths: CO1

- constant volume
- constant temperature
- adiabatically

Assuming mechanical reversibility, calculate Q , W , ΔH and ΔU for each process where $R = 8.314$ kJ/kmol.K.

OR

Calculate the total change in entropy for the following processes.

- One gram of an ideal gas $c_p = 7$ cal / gm mole K is cooled at 10 atm abs. Pressure from 500K to 300K and then expanded isothermally to 1atm.abs. pressure and 300 K. CO1
- 100 grams of lead shot $C_p = 0.03$ cal/gm°C initially at 300° C is mixed adiabatically with 100 grams of water at 30°C.

Q. 3. a) Derive the various Maxwell Relations. CO2

- 43
- b) 1 kmol of methane is stored in a container of 0.12 m³ volume. What is the pressure using (i) Ideal gas law (ii) Redlich-Kwong equation (iii) Vander Waals equation.

Given $Z = 0.83$, $P_c = 46$ bar, $T_c = 190$ K

OR

- a) Show that $C_p - C_v = R$ for an ideal gas
b) Show that

CO2

$$dH = C_p dT + \left[V - T \left(\frac{\partial V}{\partial T} \right)_P \right] dP$$

$$\mu = \left(\frac{\partial T}{\partial P} \right)_H = [T\beta - 1] \frac{V}{C_p}$$

- Q. 4. a) How do you define an ideal gas solution and ideal solution? Prove that

CO3

$$\Delta S_{mixing}^{ig} = R \sum x_i \ln(1/x_i)$$

- b) Derive the expression for change in entropy when an ideal gas changes its state from (P_1, V_1, T_1) to (P_2, V_2, T_2) .

OR

- a) Show that if Henry's Law is applied to one component in a binary mixture, Lewis Randall rule is applicable to the other component.
b) Gibb's Free energy is a generating function. Justify the statement.
c) State at least three equations of state for gases and discuss the general applicability of these equations.

CO3

- Q. 5. a) Derive Gibb's Duhem equation from fundamentals.

CO5

- b) The vapor pressure of toluene is given by the relation: $\ln P^{sat} = 13.9987 - 3096.52/(219.48 + T)$, where T is in °C and P^{sat} in kPa. What is the latent heat of vaporization at 107.2°C?

OR

- a) Find the fugacity at 20 atm and 300°C, of n-octane that obeys Van-der-Waal's equation of state, where $a=0.453.389 \text{ Jm}^3/\text{mol}^2$, $b=2.37 \times 10^{-4} \text{ m}^3/\text{mol}$.

CO3

$$P = \frac{RT}{V - b} - \frac{a}{V^2}$$

- b) Derive the relations for effect of pressure and temperature on fugacity coefficient.

- Q. 6. A gas mixture containing 25% CO, 55% H₂ and 20% inerts is used for methanol synthesis at 300 bar 623 K. If the gas coming from the catalyst chamber is in chemical equilibrium with respect to the reaction, $\text{CO} + 2\text{H}_2 \leftrightarrow \text{CH}_3\text{OH}$ What percent of carbon monoxide would have been converted, if the equilibrium constant is 1.4×10^{-4} ?

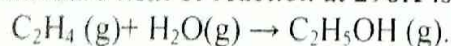
CO4

OR

- a) Develop the expression relating standard Gibbs free energy change and the equilibrium constant.

CO4

- b) The standard heat of reaction at 298K is -42.433 kJ for the reaction



Calculate the heat of reaction at 400 K. The constants in the heat capacity equation $C_p = a + bT + cT^2$ are as given below:

	a	b	c
C ₂ H ₄	11.85	119.75×10^{-3}	-36.53×10^{-6}
H ₂ O	30.38	9.62×10^{-3}	$+1.19 \times 10^{-6}$
C ₂ H ₅ OH	29.27	166.39×10^{-3}	-49.93×10^{-6}

(C_p is in J mol.K and T in K)