SHAHEED BHAGAT SINGH STATE TECHNICAL CAMPUS, FEROZEPUR

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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:

(a) What are point and path properties? Explain with examples.
(b) What is law of corresponding states? Explain how this law is modified using Pitzer's modification.
(c) What is the effect of pressure on equilibrium constant?
(e) What do you mean by Helmotz free energy & Gibb's energy.
(f) Define fugacity and fugacity coefficient?
(g) What do you mean by Joule Thomson Coefficient?
(h) What do you mean by partial properties? Give examples of partial molar properties.
(i) Define the terms Activity and Activity Coefficient.
(j) What is the significance of van Laar equation?

PART B (5×8marks)

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
i) constant volume
ii) constant temperature
iii) 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. CO1
(a). One gram of an ideal gas cp = 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.
(b). 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

b) 1 kmol of methane is stored in a container of 0.12 m^3 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

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

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. CO3

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.

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 Jm^3/mol^2, b= 2.37 x 10^{-4} m^3/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% H_2 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, $CO + 2H_2 \leftrightarrow CH_3OH$ CO4

What percent of carbon monoxide would have been converted, if the equilibrium constant is 1.4 x 10^{-4}?

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

C_2H_4 (g)+ H_2O(g) → C_2H_5OH (g).

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

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

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