

**B.TECH. SEM -IV (CHEMICAL ) 2014 COURSE (CBCS) :**  
**SUMMER - 2018**

**SUBJECT : CHEMICAL ENGINEERING THERMODYNAMICS – II**

Day : **Saturday**  
Date : **09/06/2018**

**S-2018-2273**

Time : **10.00 AM TO 01.00 PM**  
Max. Marks : **60**

**N.B.:**

- 1) All questions are **COMPULSORY**.
- 2) Figures to the right indicate **FULL** marks.
- 3) Use of steam tables / mollier diagram is **ALLOWED**.
- 4) Use of non-programmable **CALCULATOR** is allowed.
- 5) Assume suitable data if **NECESSARY**.

- Q.1** a) Establish a relation between excess Gibb's free energy and activity coefficient. [07]  
b) Elaborate the terms: "Activity in solution". [03]

**OR**

- Q.1** a) Derive the following expression for fugacity coefficient for species in solution. [06]  
$$\bar{G}_i^R = RT \ln \hat{\phi}_i .$$
  
b) Define excess property. Under what circumstances the property change of mixing and excess properties are identical? [04]

- Q.2** a) State Duhem's theorem based on phase rule. [04]  
b) Obtain an expression for criteria of phase equilibrium in multicomponent system. [06]

**OR**

- Q.2** Assuming Raoult's law to be valid prepare T-xy diagram for benzene (1) and ethyl benzene (2) system at 90 kPa. [10]

Data :  $\ln P^{sat} = A - \frac{B}{T+C}$  ; P in kPa, T in K .

	A	B	C
Benzene	13.8594	2773.78	- 53.08
Ethyl benzene	14.0045	3279.47	- 59.95

- Q.3** Estimate activity coefficients and  $(G^E / RT)$  for chloroform (1) and 1, 4 - Dioxane (2) system at 50°C. [10]

Data:

P, kPa	15.79	18.15	19.89	24.95	34.80	60.38	69.36
x <sub>1</sub>	00	0.1248	0.2000	0.3615	0.5555	0.8780	1.00
y <sub>1</sub>	00	0.2383	0.3691	0.6184	0.8378	0.9860	1.00

**OR**

**P.T.O.**

- Q.3 a)** How the partial pressures are used for testing the consistency of VLE data? [04]
- b)** Derive Gibb's – Duhem equation at constant T and P for binary system: [06]
- $$x_1 \frac{d \ln \gamma_1}{dx_1} + x_2 \frac{d \ln \gamma_2}{dx_1} = 0.$$

- Q.4 a)** Derive an expression for effect of temperature on reaction equilibrium constant. [05]
- b)** Explain the criteria of chemical reaction equilibrium by using the plot of Gibbs free energy Vs extent of reaction. [05]

**OR**

- Q.4 a)** Obtain the expression correlating reaction equilibrium constant and standard free energy change. [05]
- b)** Consider a system in which following reaction occur: [05]
- $$\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2 \quad (\text{I})$$
- $$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow \text{CO} + 4\text{H}_2 \quad (\text{II})$$
- where the number I and II indicate the value of reaction index j. if there are present initially 2 mol CH<sub>4</sub> and 3 mol H<sub>2</sub>O, determine expressions for y<sub>i</sub> as functions of ε<sub>I</sub> and ε<sub>II</sub>.

- Q.5** Iron oxide is reduced to iron by passing over it a mixture of 20% CO and 80% N<sub>2</sub> at 1200K and 1 bar. [10]
- $$\text{FeO (s)} + \text{CO (g)} \rightarrow \text{Fe (s)} + \text{CO}_2 \text{ (g)}.$$
- The equilibrium constant for this reaction is 0.403. Assuming that equilibrium is attained, calculate the weight of metallic iron produced per 100 m<sup>3</sup> of gas admitted at 1200 K, 1 bar. Gas mixture may be assumed to behave as ideal gas.

**OR**

- Q.5 a)** Write notes on: [06]
- i) Equilibrium in simultaneous reactions
  - ii) Pressure of decomposition
- b)** Write a note on : Heterogeneous reaction equilibrium for reactions in solutions. [04]
- Q.6 a)** Explain the binary solubility diagram at constant pressure. [05]
- b)** Write the expressions for activity coefficients in liquid liquid equilibrium. [05]

**OR**

- Q.6 a)** Elaborate the terms: [05]
- i) Partition coefficient
  - ii) Solubility parameters
- b)** Write the basic equations governing liquid liquid equilibrium. [05]

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