(3 Hours) **(Total Marks : 80)**

N.B. 1) Question No.1 is compulsory

2) Answer any three out of five question

3) Assume suitable data wherever necessary and state them clearly

4) Figure to the right indicate full marks

Que. 1

a) Write short note on liquid activity coefficient model. **[05]**

b) For a binary system consider a simplest excess function, the suffix margules model, $\frac{G^E}{RT} = Ax_1x_2$, What are the activity coefficients for this model? **[05]**

c) Write mass balance equations for the following with neat sketch. **[05]**

1. Mixer
2. Splitter
3. Heat exchanger

d) Draw the neat sketch of Distillation column and Write the ξ_k values for following component type in distillation Model. **[05]**

1. Heavier than heavy key
2. Heavy Key
3. Lighter than Light Key
4. Light key
5. Lighter than Light Key
6. Distributed component

Que. 2

a) Explain model non ideal flash column with neat sketch **[10]**

b) 97 % acetone from air acetone vapour mixture is to be recovered by using absorption using water as a solvent at 300 K and 10 bar. The feed entering bottom of column consists of 9 moles of air and 1 mole of acetone. The operating pressure in column are 300 K and 10 bar respectively. The absorption factor for acetone is 1.4. calculate **[10]**

i) Required flow rate of solvent

ii) Number of stages

iii) Composition of leaving vapour and liquid from absorption column

Data given: Vapour pressure of acetone = 0.322 bar

Vapour pressure of water = 0.035 bar

Que. 3 Feed stream with pure species A and B are mixed with recycle stream enter CSTR, where following reactions take place **[20]**

$$A + B \rightarrow C$$
$$C + B \rightarrow P + R$$
$$P + C \rightarrow G$$

Here, C is an intermediate, P is main product, R is bi product and G is oily waste. The plant consist of reactor, a heat exchanger to cool reactor effluent, a decanter to separate waste product G from reactants and other products and a distillation

column to separate product P. Due to formation of an azeotrope some of product (equivalent to 15 wt% of mass flow rate of component R) is retained in the column bottom. Most of the bottom product is recycled to reactor and rest is purged. Construct a Williams-otto flowsheet and develop the process equations.

Que. 4

a) Solve the following problem by Kuhn Tucker condition **[10]**

Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$

Subject to $x_1 + x_2 \leq 2$

$2x_1 + 3x_2 \leq 12$ with $x_1, x_2 \geq 0$

b) Solve the fixed point problem given by **[10]**

$$x_1 = 1 - 0.5\exp(0.7(1 - x_2))$$

$$x_2 = 2 - 0.3\exp(0.5(x_1 + x_2))$$

Using direct substitution method starting from x_1= -1 and x_2= -1.

Que. 5

a) Consider the water gas reaction, **[10]**

$$CO + H_2O \leftrightarrow CO_2 + H_2$$

At a pressure of 5 atm and temperature of 600 K. What is the equilibrium concentration?

Given Data: The Gibbs energy of reaction

$\Delta G_{f\,CO_2} = -94.26\ kcal/gmol$ $\Delta G_{f\,CO} = -32.81\ kcal/gmol$

$\Delta G_{f\,H_2O} = -54.64\ kcal/gmol$ $\Delta G_{f\,H_2} = 0\ kcal/gmol$

b) Solve the following problem by Lagrange multiplier. **[10]**

Maximize f (x,y)=x^2y

Subject to, $x^2 + y^2 = 1$

Que. 6 For the flow diagram given below find the partitions and develop precedence order **[20]**