(3 Hours) **[Total Marks 80]**

Que. 1

a) Explain overall strategy for developing unit models **[05]**

b) List out the various methods of optimization and explain in brief. **[05]**

c) Derive the Fenske's equation for distillation column **[05]**

d) Explain in details (EOS) model. **[05]**

Que. 2

a) Derive fenske equation for minimum number of stages in distillation column. **[10]**

$$N_m = \frac{ln[(\xi_{lk}(1-\xi_{hk})/(\xi_{hk}(1-\xi_{lk})]}{ln\alpha_{lk/hk}}$$

b) 95 % 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 12 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 P and Q are mixed with recycle stream enter CSTR, where following reactions take place **[20]**

$$P + Q \rightarrow X$$
$$X + Q \rightarrow S + R$$
$$S + X \rightarrow Z$$

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

$$\Delta G_{f\,CO_2} = -94.26\ kcal/gmol \quad \Delta G_{f\,CO} = -32.81\ kcal/gmol$$
$$\Delta G_{f\,H_2O} = -54.64\ kcal/gmol \quad \Delta G_{f\,H_2} = 0\ kcal/gmol$$

b) Solve graphically the following problem (Lagrange multiplier) **[10]**

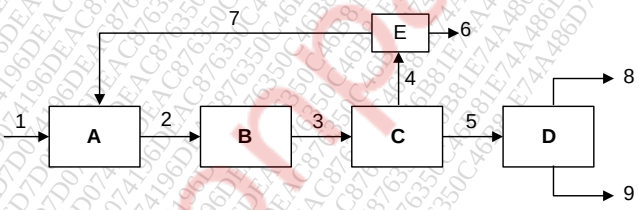
Maximize $z = 2x_1 + 3x_2$

Subject to ${x_1}^2 + {x_2}^2 \leq 20$

$x_1 x_2 \leq 8$ and $x_1, x_2 \geq 0$

Que. 6

a) Find the tear stream for the following system by BTA **[10]**



b) Explain model nonideal Flash Drum with neat sketch **[10]**