

(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]

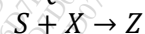
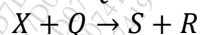
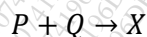
$$N_m = \frac{\ln[(\xi_{lk}(1 - \xi_{hk})/(\xi_{hk}(1 - \xi_{lk}))]}{\ln \alpha_{lk/hk}}$$

- 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]
- Required flow rate of solvent
 - Number of stages
 - 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]



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]

$$\text{Maximize } Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$$

$$\text{Subject to } x_1 + x_2 \leq 2$$

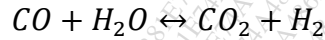
$$2x_1 + 3x_2 \leq 12 \quad \text{with } x_1, x_2 \geq 0$$

- 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]



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

Given Data: The Gibbs energy of reaction

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

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

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

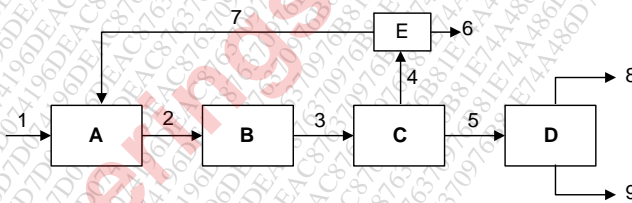
Maximize $z = 2x_1 + 3x_2$

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]