(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

Q.1). Attempt **any four**

a) Explain types of flowsheet simulation [05]

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

c) Develop the mass balances for the Mixer unit, Splitter unit and Reactor [05]

d) List out various methods of optimization and explain in brief [05]

e) Model a non-ideal flash column? [05]

Q.2) Calculate the bubble point temperature in flash column for the mixture with components, flowrates, boiling points & Antoine coefficients given in the following table:- Total Pressure is 1 bar, For Antoine equation P is in mmHg, T is in K where 99% of Benzene is recovered in the overhead and 99.5% of xylene to be recovered in bottom. [20]

Component	f (mole/hr)	Boiling Point	A	B	C
Benzene	30	353	15.9008	2788.51	-52.34
Toluene	50	383	16.0137	3096.52	-53.67
O-xylene	40	418	16.1156	3395.57	-59.44

Q.3.a) Derive the Kremser equation for absorption column? [10]

Q.3.b) Using Newton's method along with Armijo line search method to solve following eqn [10]

$$f_1 = 2x_1^2 + x_2^2 - 6 = 0$$

$$f_2 = x_1 + 2x_2 - 3.5 = 0$$

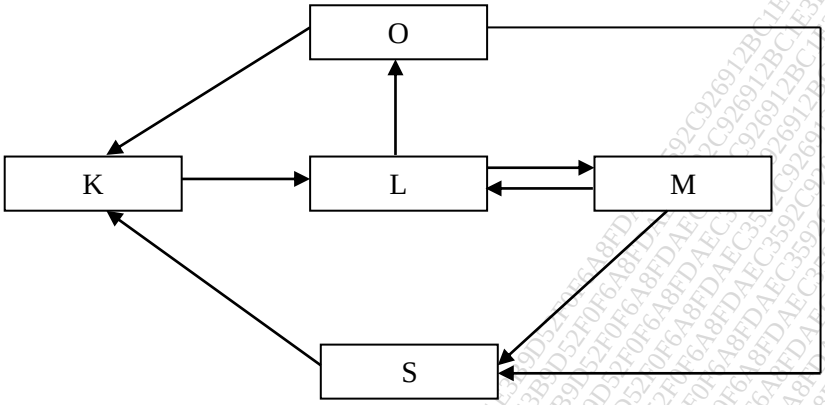
Q.4.a) Find the optimal solution for the following equations using the Kuhn Tucker method [10]

$$Min\ x^2$$

$$Subjected\ to\ -a \le x \le a$$

where $a>0$

Q.4.b) Find the tear stream for the given flowsheet [10]



Q.5) Feed streams with pure species A and B are mixed with recycle stream enter CSTR where the following reaction takes place:

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

here C is intermediate, P is the main product, E is bi product and G is the oily waste. The plant consist of a reactor, a heat exchanger to cool reactor effluent, a decanter to separate waste product from G from reactants and other products and a distillation column to separate product P. Due to formation of azeotrope some of product (equivalent to 10 wt% of mass flow rate of component E) is retained in the column bottom most of the bottom product is recycled to reactor and rest is purged. Construct a William otto flowsheet and develop the process equation without energy balance. [20]

Q.6) Consider the mixture of 40 mol% methanol, 20 mol% propanol and 40 mol% acetone perform ***TP*** Flash calculation at 1 atm and 343 K (70 ^{0}C).The activity coefficients are given by [20]

$$\ln \gamma_1 = -0.0753x_2^2 + 0.6495x_3^2 + 0.0172x_2x_3$$
$$\ln \gamma_2 = -0.0753x_1^2 + 0.557x_3^2 - 0.1678x_1x_3$$
$$\ln \gamma_3 = 0.6495x_1^2 + 0.557x_2^2 + 1.2818x_2x_1$$

Using the Antoine Equation

$$\ln P_i^0 = A_i^0 - \frac{B_i^0}{\left(C_i^0 + T\right)}$$

where P_i^0 is in mmhg and T is in K

Components	A	B	C
Methanol	18.5874	3626.55	-34.29
Propanol	17.5439	3166.38	-80.15
Acetone	16.6513	2940.46	-35.93

Find the mole compositions of both the phases. Start with the initial guess of *V/F* =0.85?

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