Practice Problem

1. A continuous fractionating column is to be designed to separate 350 gm-moles per minute of a binary mixture containing 40 % benzene and 60 % toluene by weight. The top product contain 97 % benzene by weight and bottom product contains 98 % toluene by weight. A reflux ratio of 3.5 moles to 1 mole of product is to be used. The feed is liquid entering the column at its boiling point.

   a) Determine the number of ideal palte
   b) Calculate the moles of overhead product and bottom product

   mol. wt. of benzene = 78
   mol. wt. of toluene = 92

x	0	0.1	0.20	0.3	0.4	0.50	0.60	0.70	0.80	0.90	1.0
y	0	0.185	0.36	0.50	0.61	0.70	0.78	0.84	0.90	0.95	1.0

Answer -: number of plates =15
B = 196.5 gm moles/min
D = 153.5 gm moles/min

2. A mixture of 35 mol % A and 65 mol % B is to be separated in a fracti0onating column. The concentration of A in the distillate is 93 mol % and 96 mol % of all product A is in the distillate. The feed is half vapor and reflux ration is to be 4.0. The relative volatility of A to B is 2.0. calculate the number of theoretical plates in the column and locate the feed plate.

   Answer - : Number of theoretical plate obtained = 17
   Feed is introduced on the 7th ideal plate from the top of the column

3. A quantity of 100 kg/hr of 50-50 acetone water solution is to be reduced to 10 % acetone using 30 kg/hr of 1,1,2-trichloroethylene as solvent in a multi-stage counter current extraction operation at 25 ^{0}C. Calculate the number of stages required. The equilibrium data at 25 ^{0}C for the system TCE-water is as follows :

   Mutual solubility data -:

$C_2H_3Cl_3$	99.89	84.65	70.36	60.06	43.88	26.39	20.71	9.63	2.18	1.02	0.44
Water	0.11	0.59	1.43	2.11	5.0	15.35	19.31	35.38	55.97	71.80	99.56
Acetone	0.00	14.76	28.21	37.83	51.12	60.26	59.88	54.99	41.85	27.18	0.00

   Data for tie lines

$C_2H_3Cl_3$	R - Phase Water	Acetone	$C_2H_3Cl_3$	E- phase water	Acetone
0.52	93.52	5.96	90.93	0.32	8.75
0.68	85.35	13.67	78.32	0.9	20.78

1.00	73	26	60.85	2.09	37.06
1.1	69.35	29.54	55.48	2.85	41.67
2.1	57	40.9	40	6.05	53.95
6.52	41.7	51.78	26.76	13.4	60.34

Answer -: Number of stages required is 4.7 or 5

4. A 2500 kg batch of pyridine-water solution, 50% pyridine is to be extracted with chloro-benzene three times and each time 2200 kg of solvent is to be used. Determine the concentration of pyridine in the final raffinate.

   Equilibrium tie line data for the system water-chloro-benzene-prridine at 25 ^{0}C are given below :

Pyridine	Chloro-benzene	Water	Pyridine	Chloro-benzene	Water
0	99.95	0.05	0	0.08	99.92
11.05	88.28	0.67	5.02	0.16	94.82
18.95	79.90	1.15	11.05	0.24	88.71
24.10	74.28	1.62	18.90	0.38	80.72
28.60	69.15	2.25	25.50	0.58	73.92
31.55	65.58	2.87	36.10	1.85	62.05
35.05	61.00	3.95	44.95	4.18	50.87
40.60	53.00	6.40	53.20	8.90	37.90
49.00	37.8	13.2	49.00	37.80	13.20

   Answer - : Final concentration of Pyridine in Raffinate is 1 %

5. Seeds, containing 20 % by weight of oil are extracted in a counter current plant and 90 % of the oil is recovered in a solution containing 50 % by weight of oil. If the seeds are extracted with fresh solvent and 1 kg of solution is removed in the underflow in association with every 2 kg of insoluble matter, how many ideal stages are required ?

   Answer -: Stages required = 5

6. Roasted copper ore containing copper as $CuSO_4$ is to be extracted in a counter current extractor. The feed charge to be treated per hour comprises of 10 tonnes of gangue, 1.2 tonnes of copper sulfate and 0.5 tonnes of water. The strong solution produced is to consist of 90 % H_2O and 10 % CuSO4 by weight. The recovery of $CuSO_4$ is to be 98 % of that ore. Pure water is to be used as the fresh solvent. After each stage one tonne of inert gangue retains 2 tonnes of water plus the copper sulfate dissolved in that water. Equilibrium is attained in each stage. How many stages are required ?

   Answer - : 10 stages are required

7. A gas containing 2 % A and 1 % B is to be scrubbed with a solvent in which A is 5 times as soluble as B. Show that using two column in series with separate regeneration of liquid

f4rom each column would permit recovery of A and B in relatively pure form. Use a y-x diagram to show the equilibrium and operating lines for the simultaneous absorption of A and B and estimate the ratio of A and B in the liquid from the first absorber ?

8. Ammonia is stripped from a dilute aqueous solution by countercurrent contact with air in a column containing seven sieve trays. The equilibrium relationship is $y_e = 0.8\ x_e$, and when the molar flow of air is 1.5 times that of the solution, 90% of the ammonia is removed.

(a) How many ideal stages does the column have, and what is the stage efficiency?

(b) What percentage removal would be obtained if the air flow rate were increased to 2.0 times the solution flow rate?

Answer - : Number of ideal stages = 5
Stage efficiency 72 %
More ammonia is removed by using more air

9. By means of a plate column, acetone is absorbed from its mixture with air in a nonvolatile absorption oil. The entering gas contains 30 mole percent acetone, and the entering oil is free of acetone. Of the acetone in the air, 97% is to be absorbed, and the concentrated liquor at the bottom of the tower is to contain 10 mole percent acetone. The equilibrium relationship is

$y_e = 1.9\ x_e$

Plot the operating line and determine the number of ideal stages.

Answer - : 4.3 stages are required