Mass Transfer – I (CH31001)

Tutorial Sheet No.: MT-I/NCP/2019/2

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1. A liquid mixture containing 60 mol% n-pentane and 40 mol% n-heptane is vaporized at 1 std atm pressure under differential distillation condition until 40 mol% of the mixture is distilled. What is the average composition of the total vapour distilled and the composition of the liquid left?

If the same amount of vaporization is done in an equilibrium or flash distillation, what will be the composition of the vapour distilled and the composition of the liquid left?

Equilibrium Data:

x	0.0	0.059	0.145	0.254	0.398	0.594	0.867	1.00
y	0.0	0.271	0.521	0.701	0.836	0.925	0.984	1.00

Ans. For DD, $x_W = 0.40$, $y_{D,avg} = 0.90$; For FD, $x_W = 0.426$, $y_D = 0.86$

2. A liquid mixture containing 40 mol% n-heptane (A), 60 mol% n-octane (B), at 30°C, is to be continuously flash vaporized at 1 std atm pressure to vaporize 50 mol % of the feed. What will be the composition of the vapour and liquid?

If the same liquid mixture is subjected to differential distillation at atmospheric pressure with 50 mol% of the liquid distilled, what will be the composition of the composited distillate and the residue?

Temperature-Vapour pressure Data:

Temp.(°C)	98.4	105	110	115	120	125.6
P_A(mm Hg)	760	940	1050	1200	1350	1540
P_B(mm Hg)	333	417	484	561	650	760

Ans. For FD, $x_W = 0.31$, $y_D = 0.48$; For DD, $x_W = 0.272$, $y_{D,avg} = 0.528$

3. A liquid mixture containing 50 mol% n-heptane (A), 50 mol% n-octane (B) is subjected to differential distillation at atmospheric pressure with 60 mol% of the liquid distilled. The average relative volatility may be assumed as 2.16. What will be the compositions of the composited distillate and the residue?

Ans. $y_{D,avg} = 0.613$

4. 100 moles of acetonitrile-nitromethane mixture is differentially distilled in a batch still at a pressure of 75 kPa. The feed contains 60 mole% acetonitrile. Distillation is continued till the liquid left behind in the still contains 30 mole% acetonitrile. The vapour-liquid equilibria for the system at this pressure are correlated as follows:

$y^* = 1.12\,x + 0.15$ for $0.2 \le x \le 0.4$ and

$y^* = 0.76\,x + 0.25$ for $0.4 \le x \le 0.7$,

where x and y^* refer to the mole fractions of acetonitrile in the liquid and equilibrium vapour, respectively. Find the average composition of the distillate collected.

Ans. $y_{D,avg} = 0.643$

5. An ideal solution containing 10% methanol (A), 80% ethanol (B) and 10% n-propanol (C) is flash vaporized at 80°C and 1 atm pressure. Compute the amount of liquid and vapour products and their composition. Given the vapour pressures of A, B and C at 80°C as 1302 mm Hg, 787 mm Hg and 364 mm Hg, respectively.

Ans. D = 60.0%, W = 40.0%, $x_{A,W} = 0.0701$, $x_{B,W} = 0.7833$; $x_{C,W} = 0.1456$; $y_{A,D} = 0.1193$; $y_{B,D} = 0.8111$, $y_{C,D} = 0.0696$.

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6. A liquid mixture containing 50 mol% benzene and 50 mol% toluene is to be continuously fractionated at the rate of 8500 kg/hr. A distillate containing 95 mol% benzene and a bottom product containing 10 mol% benzene are to be obtained. The feed is liquid at its bubble point. A total condenser will be used and the reflux will be returned at the bubble point. Determine (i) the product rates, kg/h; (ii) the minimum reflux ratio, (iii) the number of theoretical trays required for a reflux ratio two times the minimum, and (iv) the optimum location of the feed tray. The benzene-toluene mixture is having an average relative volatility of 2.4.
Ans. (a) D = 3704 kg/h, W = 4796 kg/h; (b) R_m = 1.289; (c) 9.5; (d) 6^{th} tray from top.

7. A solution of n-heptane and ethylbenzene containing 42 mol% n-heptane is to be continuously fractionated at 101.3 kPa pressure at the rate of 20696 kg/h to give a distillate containing 97 mol% n-heptane and a bottom product containing 1.1 mol% n-heptane. The feed enters the tower partially vaporized so that 60 mol% is liquid and 40 mol% is vapour. A total condenser will be used and the reflux will be returned at the bubble point. Determine (i) the product rates, kg/h; (ii) the minimum reflux ratio; (iii) the number of theoretical trays required at a reflux ratio 75% more than the minimum and (iv) the optimum location of the feed tray.

Equilibrium Data:

x	0.0	0.08	0.250	0.485	0.580	0.790	1.0
y	0.0	0.23	0.514	0.730	0.790	0.904	1.0

Ans. (a) D = 8545.35 kg/h, W = 12150.65 kg/h; (b) R_m = 1.425; (c) 12; (d) 8^{th} tray from top.

8. A solution of carbon tetrachloride (CCl_4) and carbon disulphide (CS_2) containing 60 mol% CCl_4 is to be continuously fractionated at standard atmospheric pressure at the rate of 24560 kg/h. The distillate product is to contain 95 mol% CS_2, the residue 1.0 mol% CS_2. The feed will be 50 mol% vaporized before it enters the tower. A total condenser will be used and the reflux will be returned at the bubble point. Determine (i) the product rates, kg/h; (ii) the minimum reflux ratio; (iii) the number of theoretical trays required at a reflux ratio 1.5 times the minimum and (iv) the location of the feed tray.

Equilibrium Data:

x	0.0	0.0296	0.0615	0.1106	0.1435	0.2585	0.3908
y	0.0	0.0823	0.1555	0.2660	0.3325	0.4950	0.6340

0.5318	0.6630	0.7574	0.8604	1.00
0.7470	0.8290	0.8780	0.9320	1.00

Ans. (a) D = 6632 kg/h, W = 17928 kg/h; (b) R_m = 1.878; (c) 11.5; (d) 7^{th} tray from top.

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