TE Chemical VI QP Code 13645, May 18

Solution - MTO II

Q.2(b)

A liquid feed consisting of 1200 g moles of mixture containing 30% naphthalene, 70% dipropylene glycol is differentially distilled at 100 mm Hg pressure and final distillate contains 55% of the feed solution. The VLE data are –

x	8.4	11.6	28.0	50.6	68.7	80.6	88
y	22.3	41.1	62.9	74.8	80.2	84.4	88

Determine the amount of distillate determine the concentration of naphthalene residue and distillate.

Calculations :

$$F = 1200 \text{ gmol}$$

$$F = D - W$$

$$D = 0.55 \times 1200 = 660 \text{ gmol}$$

$$\text{Amount of distillate, } D = 660 \text{ gmol}$$

$$W = 1200 - 660 = 540 \text{ gmol}$$

Q2b

From Rayleigh's equation

$$\ln\frac{F}{W} = \int_{x_W}^{x_F} \frac{dx}{y^* - x}$$

x_W is calculated from the graphical method, for which the integral term is the above equation is balanced :

$\ln(F/W) = \ln(1200/540) = 0.7985$

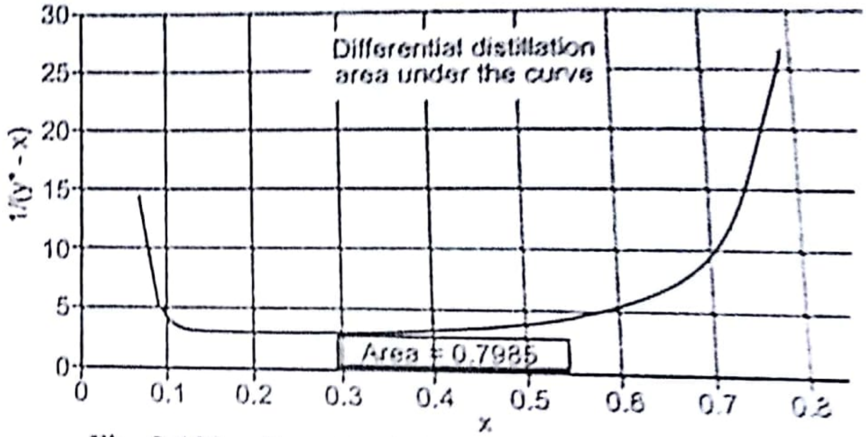

Fig. 3.128 : Graphical Integration for Problem 3.5

The area of 0.7985 is obtained for $x_W = 0.07$

$$F\,x_F = D\,y_{D,avg} + W\,x_W$$

$$660 \times y_{D,avg} = 1200 \times 0.3 - 540 \times 0.07$$

$$y_{D,avg} = 0.4882$$

Concentration of naphthalene in residue = 7%

Concentration of naphthalene in distillate = 48.82%

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Q (6b)

S.No. Marks

A solution containing 5% acetaldehyde and 95 toluene is to be extracted with water in a five stage crosscurrent extraction unit to extract acetaldehyde. Toluene and water are essentially insoluble. If 25 kg of water each time are used per 100 kg of feed, calculate the amount of acetaldehyde extracted and final concentration of exit soln. equilibrium relationship is

5 % acetaldehyde

$Y = 2.20 X$

Y = kg acetaldehyde / kg H_2O extract

X = kg acetaldehyde / kg toluene (raffinate)

$\frac{\text{kg acetaldehyde}}{\text{kg toluene}}$

$= \frac{5}{95} = 0.0526$

$\frac{A}{B} = \frac{95}{25} = 3.8$

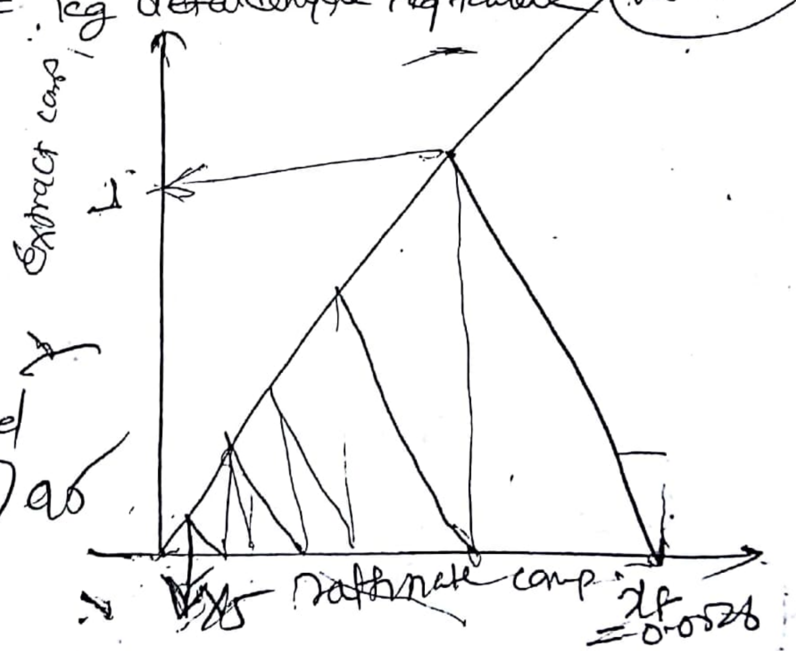
$\text{slope} = -\frac{A}{B}$

$X_5 = 0.005363$

Amt of acetaldehyde extracted

$= (0.0526 - 0.005363)\, 95$

$= 4.49$ kg



t_B = 0.23...

= 23.0914 hours (Ans.)

Q 4(a)

Ex. 5.5 : A copper sulphate solution at 0.18 mol/liter is passed through a 99.3 g, 30.5 cm high bed of amberlite ion exchange resin at 82.2 cm³/min. Outlet data were as follows :

Time (minutes)	7	8	8.5	9	10	11	12	13	13.5	14.5	15
Water conc. (mol/liter)	0	0.0033	0.0075	0.0157	0.0527	0.1063	0.1433	0.1634	0.1709	0.1778	0.1800

If break-through is defined here as being when c/c_0 reaches 0.05, find the following :

(a) Breakthrough time.

(b) Fraction of total resin capacity used by breakthrough time.

(c) Height of "zone" of unspent (but not unused) bed in column.

(d) Saturation capacity of resin.

Sol. : First plot c/c_0 against time :

Time (mins)	0	7	8	8.5	9	10
c/c_0	0	0	0.018333	0.041667	0.087222	0.292778
Time (mins)	11	12	13	13.5	14.5	15
c/c_0	0.590556	0.796111	0.907778	0.949444	0.987778	1

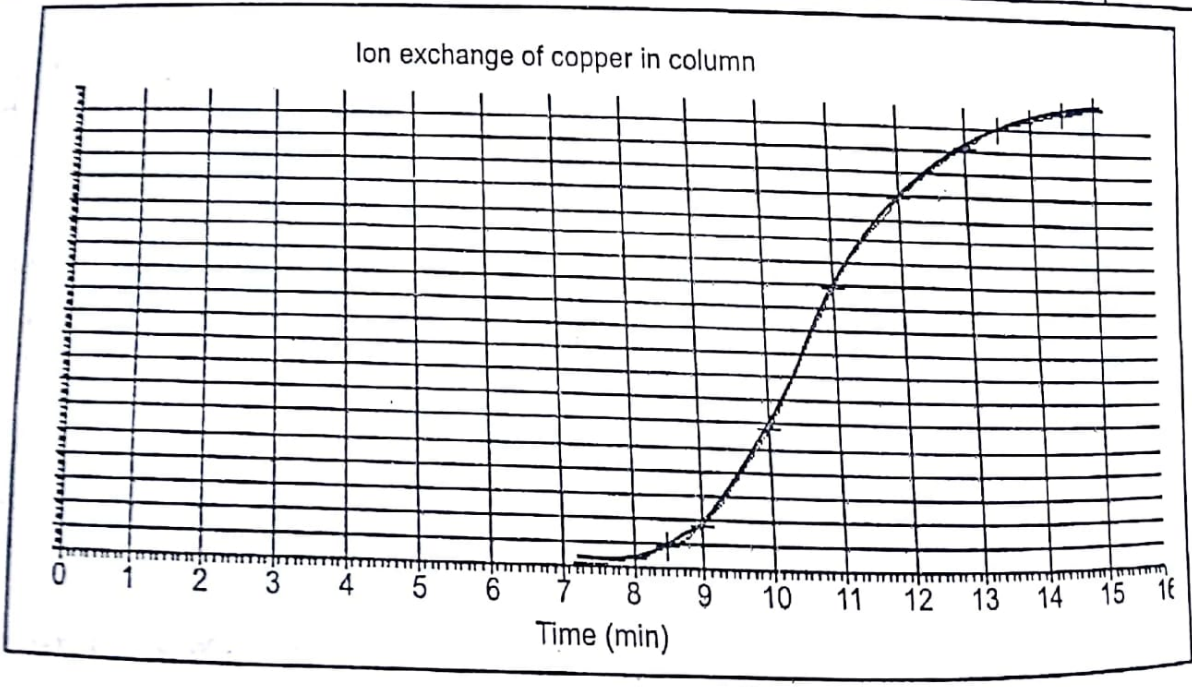


Fig. 5.28 : Break Through Curve For Ex. 5.5

Reading graph, $t_B = 8.6$ minutes and $t_D = 15.0$ minutes.

Area under curve to 15 minutes is 4.163194 minutes by Simpson's Rule

Stoichiometric capacity $t_T = 15.0 - 4.163194 = 10.836806$ minutes

Area under curve to 8.6 minutes is 0.03 minutes by Simpson's Rule (Ans.)

Capacity used by breakthrough, $t_U = 8.6 - 0.03 = 8.57$ minutes

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c Bollman extractor
d classification of membrane separation operations

Q. 4 (a) ~~Q. 5~~ (c) continued

Capacity used $= \frac{t_U}{t_T} = \frac{8.57}{10.836806} = 0.7908234$

$H_{zone} = H_{total} - H_{spent} = H_{total} - H_{total}\frac{t_U}{t_T} = 30.5\,(1 - 0.7908234) = 6.379$ cm

To use up stoichiometric capacity,

We would feed 10.836 min × 82.2 cm^3/min = 890.78 cm^3

0.89078 litres × 0.18 mol/liter = 0.1603 mol processed

0.1603413 mol × 99.3 grammes = 1.6147×10^{-3} mol per gramme of solid.

(Ans.)

g 50

SOLVED PROBLEMS

Problem 1.1 : A salt solutions weighing 10,000 kg with 30 wt. % Na_2CO_3 is cooled to 293 K. The salt crystallizes the decahydrate. What will be the yield of $Na_2CO_3 \cdot 10\ H_2O$ crystals if the solubility is 21.5 kg anhydrous Na_2CO_3/100 kg of total water. Do this for following cases :

(a) Assume that no water is evaporated.

(b) Assume that 3% of the total weight of the solution is lost by evapouration of water in cooling.

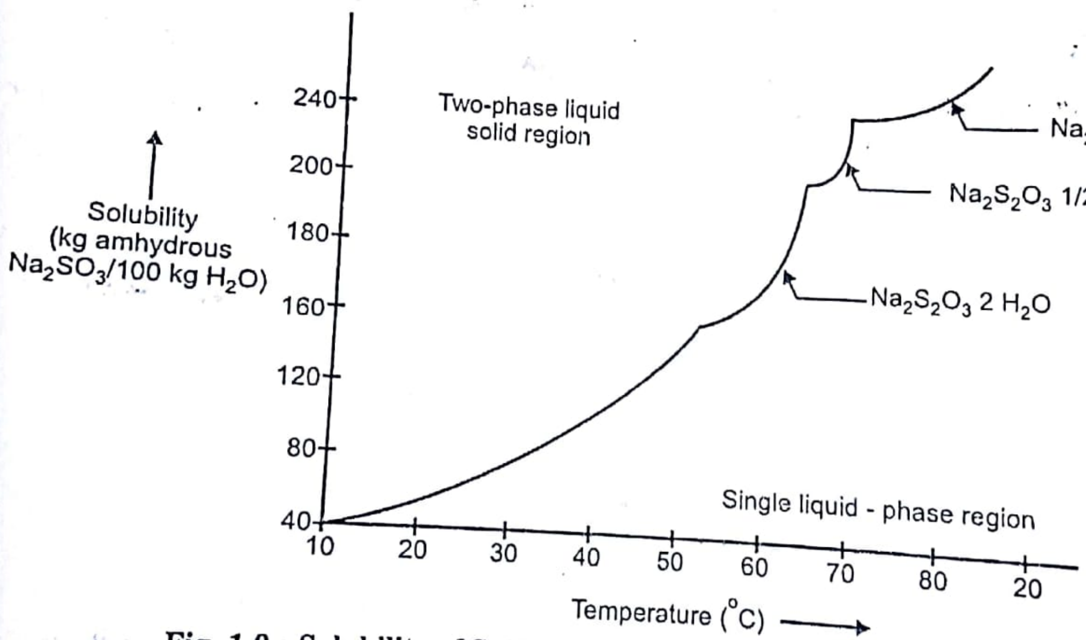

Fig. 1.9 : Solubility of Sodium Thiosulfate, $Na_2S_2O_3$, in Water

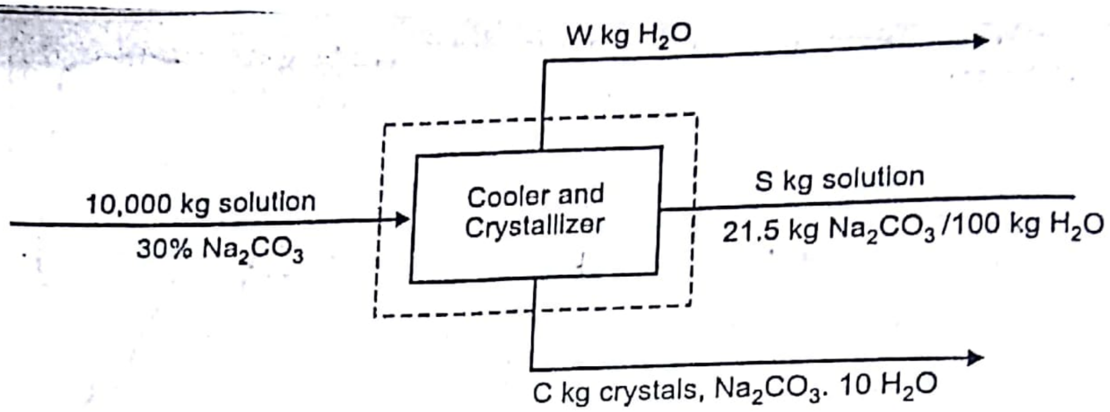

Fig. 1.10 : Process Flow for Crystallization in Example 1

Sol. : The molecular weights are 106.0 for Na_2CO_3, 180.2 for 10 for $10H_2O$ and 286.2 for Na_2CO_3. $10H_2O$. The press flow diagram is shown in Fig. 1.10, with W being kg. H_2O evaporated, S kg solution (mother liquor), and C kg crystals of Na_2CO_3 $10H_2O$. Making a material balance around the dashed-line box for water for part (a), where W = 0.

$$0.70\,(10000) = \frac{100}{100+21.5}\,(S) + \frac{180.2}{286.2}\,(C) + 0 \qquad \ldots (A)$$

where, (180.2) (286.2) is wt. fraction of water in the crystals. Making a balance for Na_2CO_3.

$$0.30\,(10000) = \frac{21.5}{100+21.5}\,(S) + \frac{106.0}{286.2}\,(C) + 0 \qquad \ldots (B)$$

Solving the two equations simultaneously, C = 6370 kg of $Na_2CO_3.10H_2O$ Crystals and *S = 3630 kg solution.*

For part (b), W = 0.03 (10000) 300 kg H_2O. Equation (A) becomes

$$0.70\,(10000) = \frac{100}{100+21.5}\,(S)\,\frac{180.2}{286.2}\,(C) + 300 \qquad \ldots (C)$$

Equation (B) does not change, since no salt is in the W stream. Solving equations (B) and (C) *simultaneously*. C = *6630* kg of Na_2CO_3. 10 H_2 O Crystals and S = 3070 kg solution.

(Ans.)