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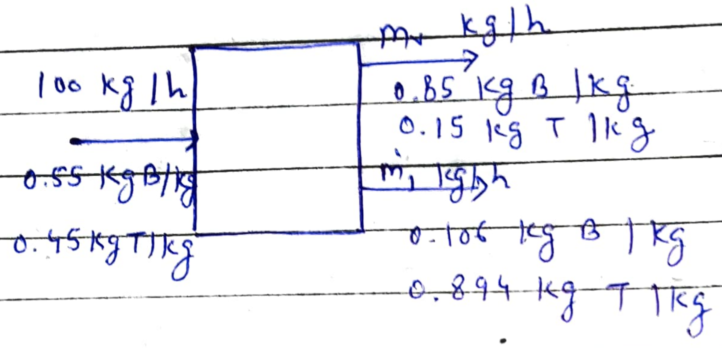
Assignment - 1

Problem 4.3



a) Input + generation - output - consumption = accumulation.
Since, this is steady state, accumulation = 0.
Also, balanced quantity is total mass
Generation = 0 and Consumption = 0.

Thus, Input = Output

for total mass, $100 = \dot{m}_v + \dot{m}_l$ — (1)

for Benzene, $(0.55 \times 100) = 0.85\dot{m}_v + 0.106\dot{m}_l$

$55 = 0.85\dot{m}_v + 0.106\dot{m}_l$ — (2)

putting $\dot{m}_l = 100 - \dot{m}_v$ from (1)

$55 = 0.85\dot{m}_v + 10.6 - 0.106\dot{m}_v$

$44.4 = 0.744\dot{m}_v$

$\boxed{\dot{m}_v = 59.67 \text{ kg/h}}$

$\dot{m}_l = 100 - 59.67$

$\boxed{\dot{m}_l = 40.33 \text{ kg/h}}$

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b)

100 kg	m_v (kg)
0.55 kg B/kg	0.85 kg B/kg
0.45 kg T/kg	0.15 kg T/kg
	m_l (kg)
	0.106 kg B/kg
	0.894 kg T/kg

Input + generation − output − consumption = accumulation

Since, balanced quantity is total mass

Generation = 0, consumption = 0

Also, accumulation = 0 (No buildup within system).

Input = Output, $100 = m_v + m_l$ — ①

On Benzene, $0.55 \times 100 = 0.85 m_v + 0.106 m_l$ — ②

from ① & ②

$$\boxed{\begin{aligned} m_v &= 59.67\ kg \\ m_l &= 40.33\ kg \end{aligned}}$$

c) Possible explanations to this phenomena could be -

① The process in not occuring at a steady state.

② Presence of foreign substances in the stream being fed.

③ Incorrect flow rates.

④ Occurance of chemical reaction.

⑤ Errors in measurement.

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Problem 4.6

a) 3 independent mass balances can be written for this system.

b) $x_2 + y_2 = 1$ — ① $y_4 + z_4 + 0.7 = 1$ — ②

also for A, we can write mass balance as -
$5300(x_2) = \dot{m}_3 + 0.7(1200)$ — ③

Similarly for B,
$\dot{m}_1(0.03) + 5300(y_2) = y_4(1200) + 0.6(\dot{m}_5)$ — ④

for C
$0.97(\dot{m}_1) = z_4(1200) + 0.4(\dot{m}_5)$ — ⑤

Unknowns = $(\dot{m}_1, \dot{m}_3, \dot{m}_5, x_2, y_2, y_4, z_4)$
we have 5 equations.
Thus ~~four~~ two unknown must be specified.

c) $y_2 + x_2 = 1$
$y_2 = 1 - x_2 \rightarrow$ given

Balancing A
$5300x_2 = (\dot{m}_3 + (1200)(0.70))$

Total mass balance
$(m_1 + 5300) = (\dot{m}_3 + 1200 + \dot{m}_5)$
given

B balance
$(0.03\dot{m}_1 + 5300x_2) = (1200y_4 + 0.60\dot{m}_5)$
$z_4 = 1 - 0.70 - y_4$

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Prob 4.7

a) Three independent balances can be written (for $C_6H_{13}OH$, CH_3COOH and H_2O)

b) CH_3COOH balance

$$(0.115)(400) = \dot{m}_E(0.096) + \dot{m}_R(0.005) \quad -①$$

Water balance

$$0.885(400) = \dot{m}_R(0.995)$$

$$\boxed{\dot{m}_R = 356 \text{ g/min}}$$

put $\dot{m}_R$ in ①

$$\boxed{\dot{m}_E = 461 \text{ g/min}}$$

Total mass balance

$$\dot{m}_C + 400 = \dot{m}_R + \dot{m}_E$$

$$\dot{m}_C = 356 + 461 - 400$$

$$\dot{m}_C = 417 \text{ g/min}$$

(c) In feed mix, amount of acetic acid $= (0.115)(400)$
$= 46.0$ g/min

In 0.5% mix, amount of acetic acid $= (356)(0.005)$
$= 1.78$

difference $= 46 - 1.78 =$
$= 44.22$ g/min $-①$

Now $(0.096)(461) = 44.22$ g/min $-②$

① = ②

Hence proved

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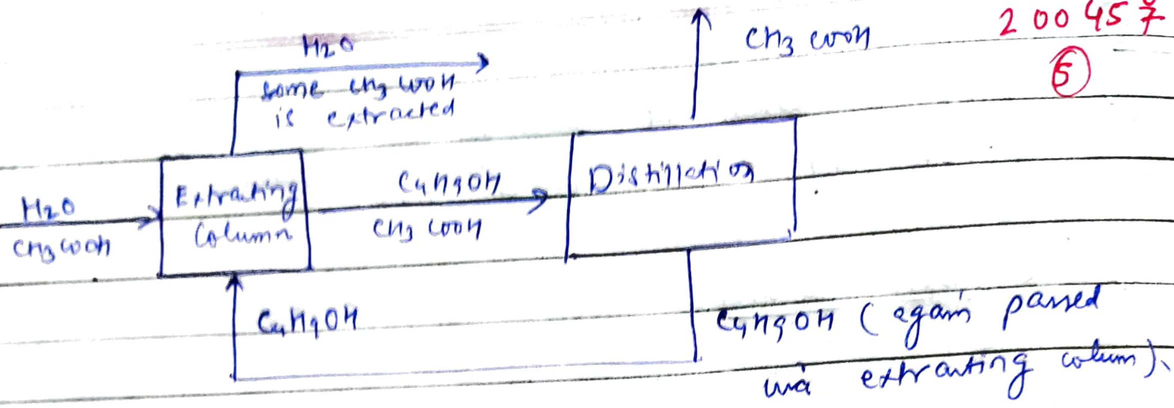
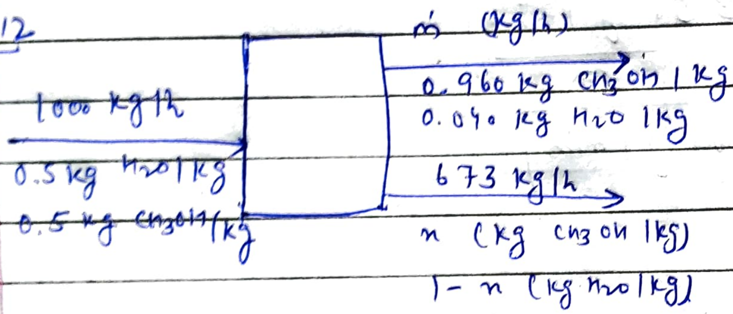
d)



Problem 4.12

a)



b) Total mass balance: $1000 = \dot{m} + 673$

$\dot{m} = 327$

CH_3OH balance :-

$0.5(10^3) = 0.96(\dot{m}) + 673(x)$

$x = 0.276$ kg CH_3OH / kg

$1-x = 0.724$ kg H_2O / kg

$$\frac{673\ \text{kg}}{\text{h}} \left| \frac{0.276\ \text{kg}\ CH_3OH}{\text{kg}} \right| \frac{1000\ \text{g}}{\text{kg}} \left| \frac{\text{mol}\ CH_3OH}{32\ \text{g}\ CH_3OH} \right.$$

molar flow rate of CH_3OH $= 5.80 \times 10^3$ mol CH_3OH/h

$$\frac{673\ \text{kg}}{\text{h}} \left| \frac{0.724\ \text{kg}\ H_2O}{\text{kg}} \right| \frac{1000\ \text{g}}{\text{kg}} \left| \frac{\text{mol}\ H_2O}{18\ \text{g}\ H_2O} \right.$$

Molar flow rate of $H_2O = 2.71 \times 10^4$ mol H_2O/h

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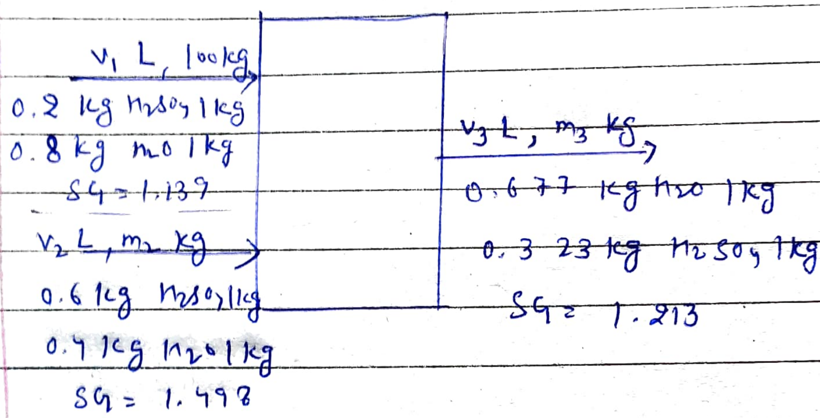
Mole fraction of $CH_3OH = \dfrac{5.8 \times 10^3}{5.8\times10^3 + 2.71\times10^4} = 0.176$ mol CH_3OH / mol.

Problem 4.16

a) $\dfrac{4.0 \text{ mol } H_2SO_4}{L \text{ soln}} \left| \dfrac{0.098 \text{ kg } H_2SO_4}{\text{mol } H_2SO_4} \right| \dfrac{L \text{ of soln}}{1.213 \text{ kg soln}} = 0.323$ (kg H_2SO_4 / kg soln)

b)



Total mass balance : $100 + m_2 = m_3$ — (1)

Water balance, $0.8\,(100) + 0.4\,(m_2) = (0.677)\, m_3$ — (2)

Solving (1) & (2) $m_2 = 44.4$ kg and $m_3 = 144$ kg

$v_1 = \dfrac{100}{1.139} = 87.80$ L of 20% soln.

$v_2 = \dfrac{44.4}{1.498} = 29.64$ L of 60% soln.

$\dfrac{v_1}{v_2} = \dfrac{87.80}{29.64} = 2.96$ (L 20% soln / L 60% soln)

c) $\dfrac{1250 \text{ kg}}{h} \left| \dfrac{44.4 \text{ kg}}{144 \text{ kg}} \right| \dfrac{L}{1.498 \text{ kg soln}} = 257$ L/h.