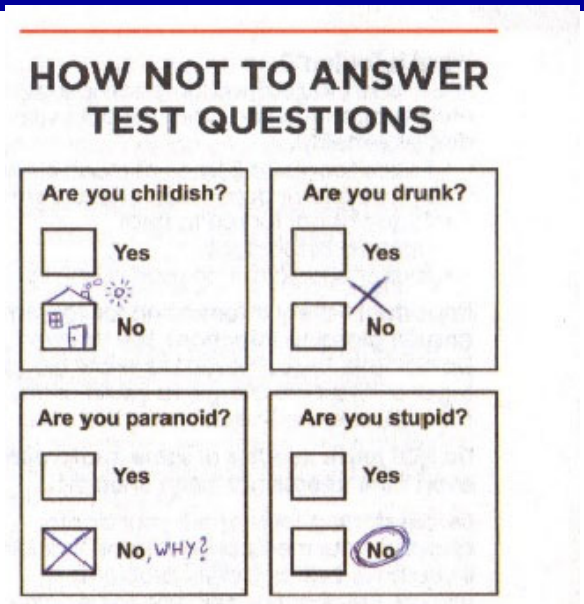
Crazy Test Answers



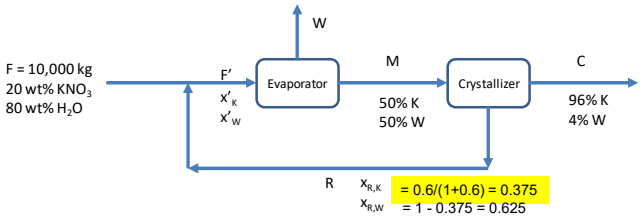
1

Class 9
Practice Multi-Unit DOF

- Questions?
- 3 Worksheets
- Problem 4.31

2

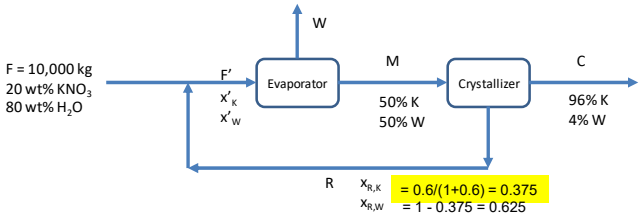
1. Fresh feed containing 20% by weight KNO_3 in H_2O is combined with a recycle stream and fed to an evaporator where the water content is reduced. The concentrated solution leaving the evaporator, containing 50% KNO_3, is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO_3 and 4% water. The supernatant liquid (liquid in equilibrium with crystals) from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO_3 per 1.0 kg of H_2O. The objective is to complete the mass balance showing all stream values and compositions.



	Unknowns	# of U	BE	OE	DOF
Evap					
Cryst					
Mixer					
Overall					

3

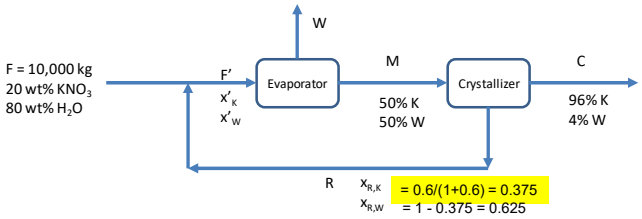
1. Fresh feed containing 20% by weight KNO_3 in H_2O is combined with a recycle stream and fed to an evaporator where the water content is reduced. The concentrated solution leaving the evaporator, containing 50% KNO_3, is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO_3 and 4% water. The supernatant liquid (liquid in equilibrium with crystals) from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO_3 per 1.0 kg of H_2O. The objective is to complete the mass balance showing all stream values and compositions.



	Unknowns	# of U	BE	OE	DOF
Evap	F', x'_k, W, M	4	2	0	2
Cryst					
Mixer					
Overall					

4

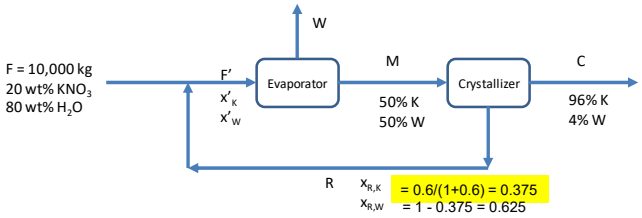
1. Fresh feed containing 20% by weight KNO_3 in H_2O is combined with a recycle stream and fed to an evaporator where the water content is reduced. The concentrated solution leaving the evaporator, containing 50% KNO_3, is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO_3 and 4% water. The supernatant liquid (liquid in equilibrium with crystals) from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO_3 per 1.0 kg of H_2O. The objective is to complete the mass balance showing all stream values and compositions.



	Unknowns	# of U	BE	OE	DOF
Evap	F', x'_k, W, M	4	2	0	2
Cryst	M, R, C	3	2	0	1
Mixer					
Overall					

5

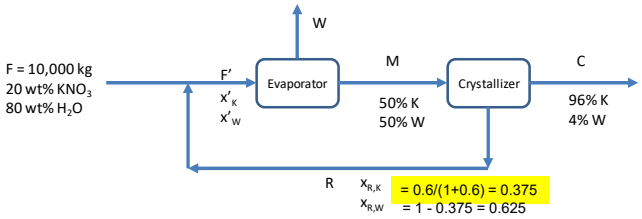
1. Fresh feed containing 20% by weight KNO_3 in H_2O is combined with a recycle stream and fed to an evaporator where the water content is reduced. The concentrated solution leaving the evaporator, containing 50% KNO_3, is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO_3 and 4% water. The supernatant liquid (liquid in equilibrium with crystals) from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO_3 per 1.0 kg of H_2O. The objective is to complete the mass balance showing all stream values and compositions.



	Unknowns	# of U	BE	OE	DOF
Evap	F', x'_k, W, M	4	2	0	2
Cryst	M, R, C	3	2	0	1
Mixer	R, x'_k, F'	3	2	0	1
Overall					

6

1. Fresh feed containing 20% by weight KNO_3 in H_2O is combined with a recycle stream and fed to an evaporator where the water content is reduced. The concentrated solution leaving the evaporator, containing 50% KNO_3, is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO_3 and 4% water. The supernatant liquid (liquid in equilibrium with crystals) from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO_3 per 1.0 kg of H_2O. The objective is to complete the mass balance showing all stream values and compositions.

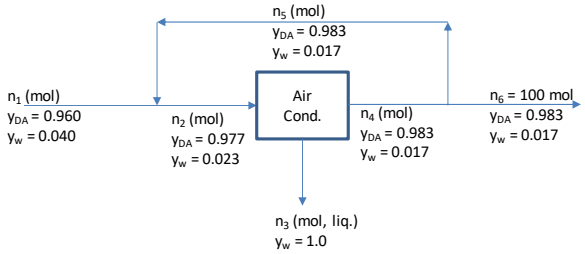


	Unknowns	# of U	BE	OE	DOF
Evap	F', x'_k, W, M	4	2	0	2
Cryst	M, R, C	3	2	0	1
Mixer	R, x'_k, F'	3	2	0	1
Overall	W, C	2	2	0	0

How do you start?

7

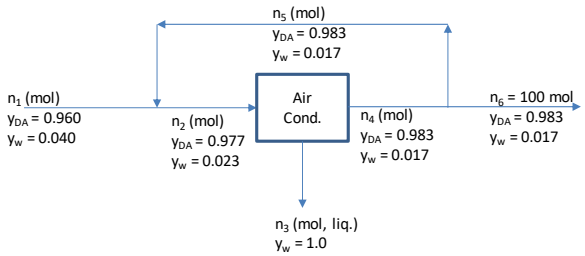
2.



	Unknowns	# of U	BE	OE	DOF
Air cond					
Splitter					
Mixer					
Overall					

8

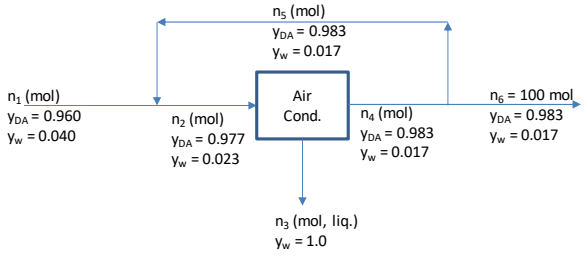
2.



	Unknowns	# of U	BE	OE	DOF
Air cond	n_2, n_3, n_4	3	2	0	1
Splitter					
Mixer					
Overall					

9

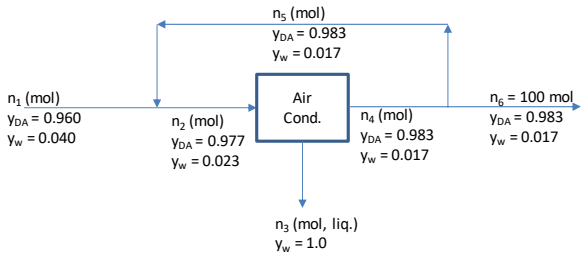
2.



	Unknowns	# of U	BE	OE	DOF
Air cond	n_2, n_3, n_4	3	2	0	1
Splitter	n_4, n_5	2	1	0	1
Mixer					
Overall					

10

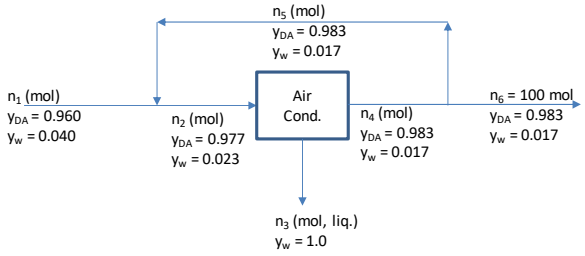
2.



	Unknowns	# of U	BE	OE	DOF
Air cond	n_2, n_3, n_4	3	2	0	1
Splitter	n_4, n_5	2	1	0	1
Mixer	n_1, n_2, n_5	3	2	0	1
Overall					

11

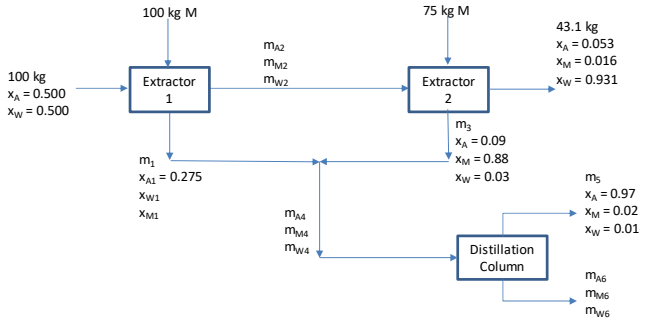
2.



	Unknowns	# of U	BE	OE	DOF
Air cond	n_2, n_3, n_4	3	2	0	1
Splitter	n_4, n_5	2	1	0	1
Mixer	n_1, n_2, n_5	3	2	0	1
Overall	n_1, n_3	2	2	0	0

12

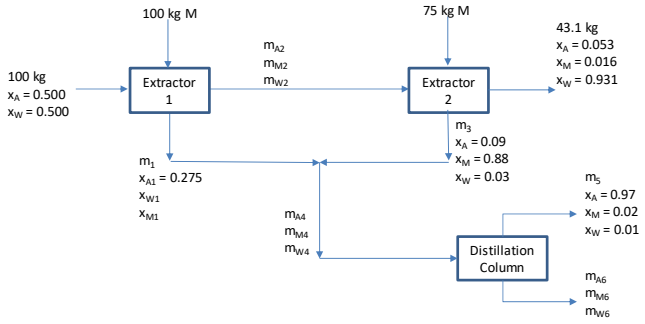
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1					
Ext 2					
Dist Col					
Mixer					
Overall					

13

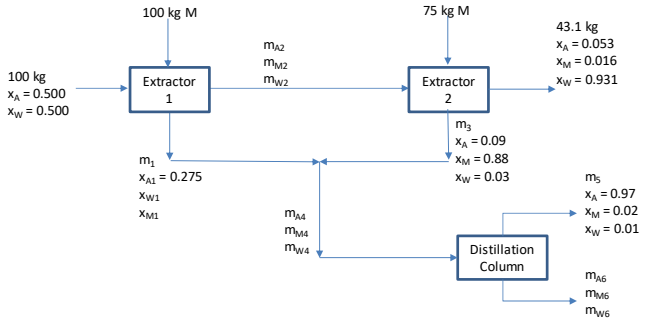
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2					
Dist Col					
Mixer					
Overall					

14

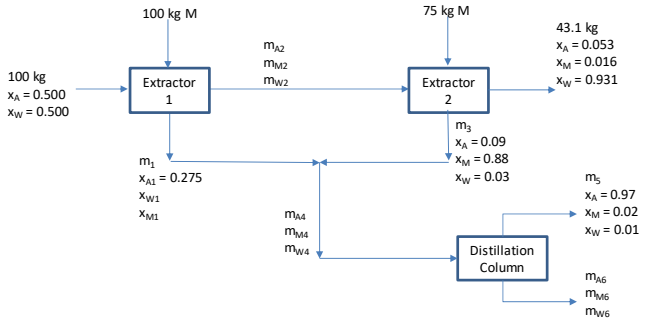
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col					
Mixer					
Overall					

15

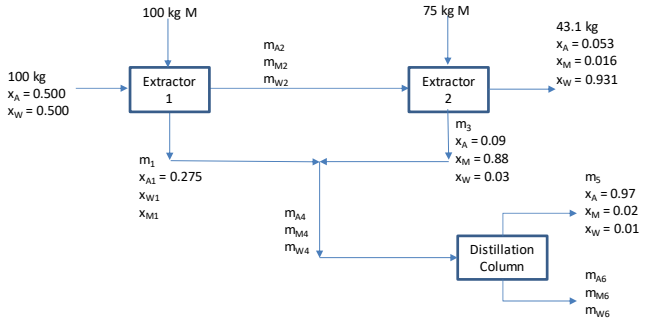
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col	m_{A4}, m_{M4}, m_{W4}, m_5, m_{A6}, m_{M6}, m_{W6}	7	3	0	4
Mixer					
Overall					

16

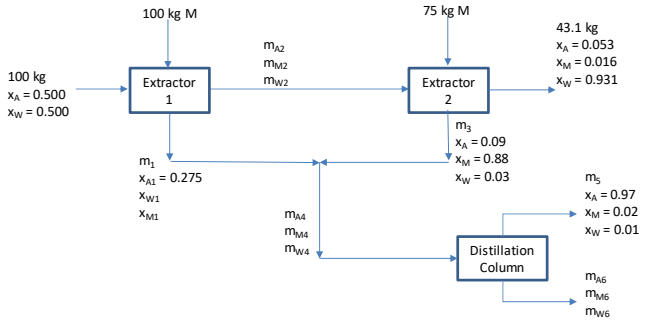
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col	m_{A4}, m_{M4}, m_{W4}, m_5, m_{A6}, m_{M6}, m_{W6}	7	3	0	4
Mixer	m_1, x_{M1}, m_3, m_{A4}, m_{M4}, m_{W4}	6	3	0	3
Overall					

17

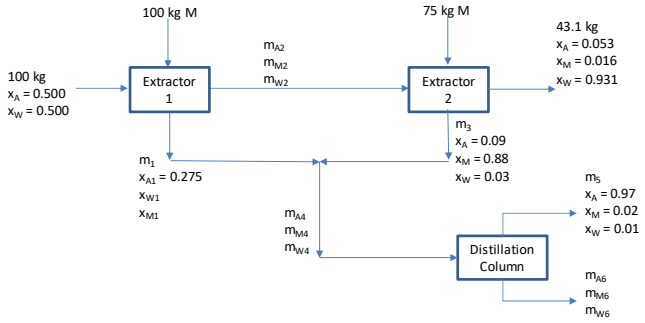
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col	m_{A4}, m_{M4}, m_{W4}, m_5, m_{A6}, m_{M6}, m_{W6}	7	3	0	4
Mixer	m_1, x_{M1}, m_3, m_{A4}, m_{M4}, m_{W4}	6	3	0	3
Overall	m_5, m_{A6}, m_{M6}, m_{W6}	4	3	0	1

18

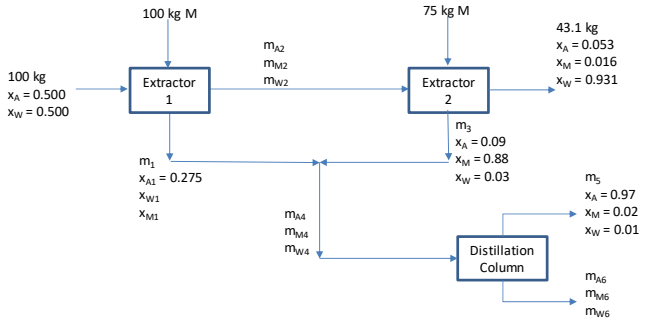
3.



	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col	m_{A4}, m_{M4}, m_{W4}, m_5, m_{A6}, m_{M6}, m_{W6}	7	3	0	4
Mixer	m_1, x_{M1}, m_3, m_{A4}, m_{M4}, m_{W4}	6	3	0	3
Overall	m_5, m_{A6}, m_{M6}, m_{W6}	4	3	0	1
Combined Extractors					

19

3.

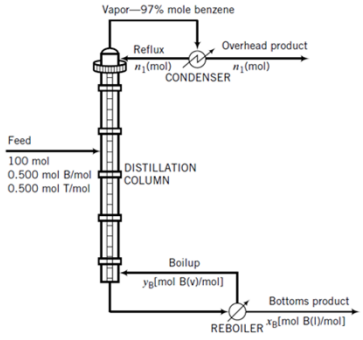


	Unknowns	# of U	BE	OE	DOF
Ext 1	m_{A2}, m_{M2}, m_{W2}, m_1, x_{M1}	5	3	0	2
Ext 2	m_{A2}, m_{M2}, m_{W2}, m_3	4	3	0	1
Dist Col	m_{A4}, m_{M4}, m_{W4}, m_5, m_{A6}, m_{M6}, m_{W6}	7	3	0	4
Mixer	m_1, x_{M1}, m_3, m_{A4}, m_{M4}, m_{W4}	6	3	0	3
Overall	m_5, m_{A6}, m_{M6}, m_{W6}	4	3	0	1
Combined Extractors	m_1, x_{M1}, m_3	3	3	0	0

20

4.31 (3rd Ed)
4.42 (4th Ed)

9.1. An equimolar liquid mixture of benzene and toluene is separated into two product streams by distillation. A process flowchart and a somewhat oversimplified description of what happens in the process follow:



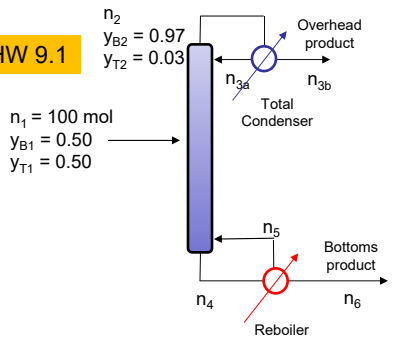
Inside the column a liquid stream flows downward and a vapor stream rises. At each point in the column some of the liquid vaporizes and some of the vapor condenses. The vapor leaving the top of the column, which contains 97 mole% benzene, is completely condensed and split into two equal fractions: one is taken off as the overhead product stream, and the other (the **reflux**) is recycled to the top of the column. The overhead product stream contains 89.2% of the benzene fed to the column. The liquid leaving the bottom of the column is fed to a partial reboiler in which 45% of it is vaporized. The vapor generated in the reboiler (the **boilup**) is recycled to become the rising vapor stream in the column, and the residual reboiler liquid is taken off as the bottom product stream. The compositions of the streams leaving the reboiler are governed by the relation:

$$\frac{y_B/(1-y_B)}{x_B/(1-x_B)} = 2.25$$

where y_B and x_B are the mole fractions of benzene in the vapor and liquid streams, respectively.

21

HW 9.1



A. Vapor leaving the top is completely condensed and split into two equal fractions

B. Overhead product stream contains 89.2% of benzene fed to the column.

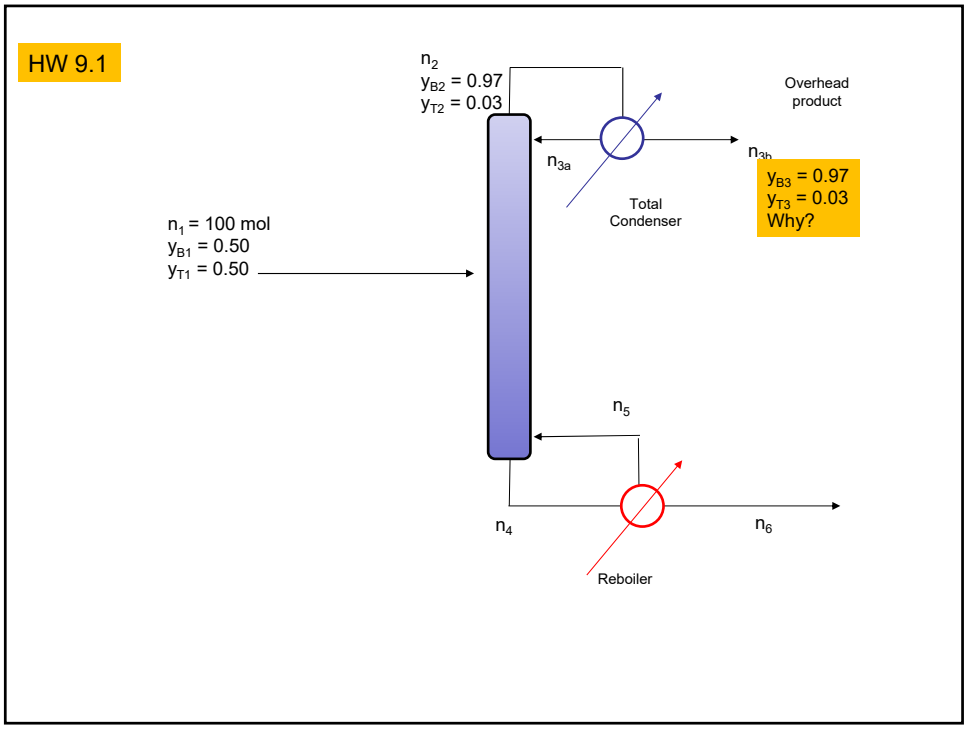
C. Liquid leaving the bottom of the column is fed to a partial reboiler in which 45% of it is vaporized. ("It" means liquid stream fed to reboiler, or n_4)

D. The composition of the streams leaving the reboiler are governed by the equation:

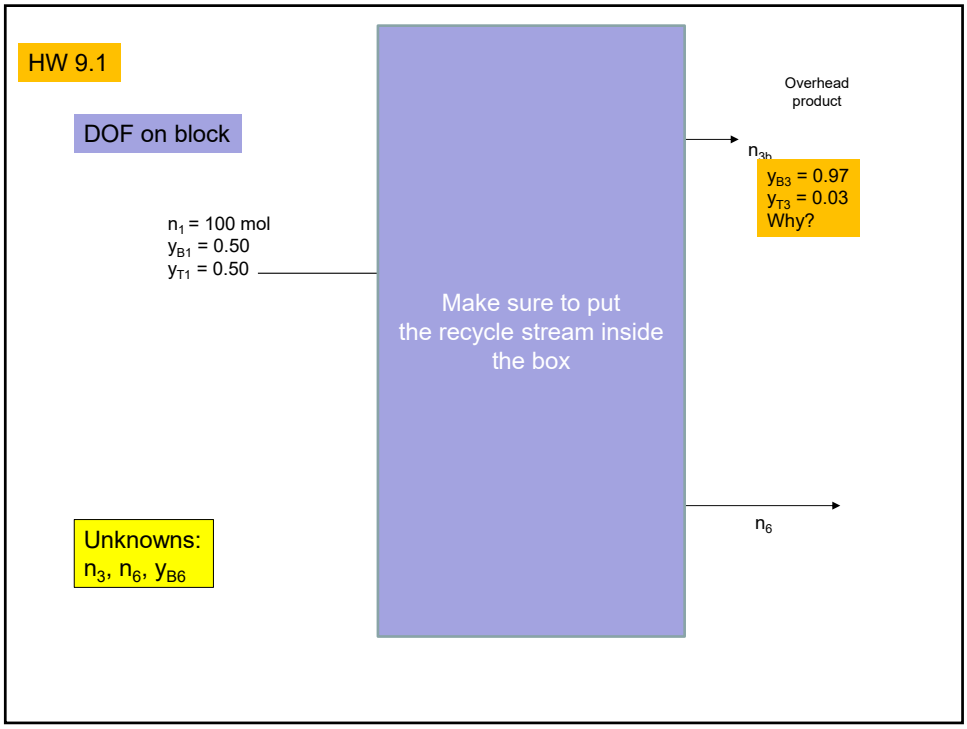
$$\frac{y_B/(1-y_B)}{x_B/(1-x_B)} = 2.25$$

1. Which streams are gas and which are liquid?
2. What are the different subunits for balance equations?
3. What are the unknowns in each subunit?
4. Translate the clues into "additional equations".
5. Perform the DOF analysis on each unit.
6. Write out the logic (with equations) that will solve for all unknown variables.
7. Solve for the 4 variables asked for in the problem statement (what variables are wanted?).

22


HW 9.1
n_2
y_{B2} = 0.97
y_{T2} = 0.03
Overhead product
n_{3a}
n_{3b}
y_{B3} = 0.97
y_{T3} = 0.03
Why?
Total Condenser
n_1 = 100 mol
y_{B1} = 0.50
y_{T1} = 0.50
n_5
n_4
n_6
Reboiler

23


HW 9.1
DOF on block
Overhead product
n_{3b}
y_{B3} = 0.97
y_{T3} = 0.03
Why?
n_1 = 100 mol
y_{B1} = 0.50
y_{T1} = 0.50
Make sure to put the recycle stream inside the box
n_6
Unknowns:
n_3, n_6, y_{B6}

24