

SOLUTION

Homework # 5 - Spring 2010

Problem statement:

A distillation column is to be used for the separation of hexane and octane. The column includes a total condenser and a partial reboiler. It is desired to produce a hexane-rich stream of 99% purity, and an octane-rich stream of 99% purity. A saturated liquid feed stream is supplied to the column at 100 moles/hr. Use the McCabe-Thiele technique to determine the number of equilibrium stages (in the column) required, the feed composition (assuming feed at optimal location), and the distillate, bottoms, rectifier liquid and vapor, and stripper liquid and vapor flow rates for each of the following sets of operating conditions:

	R	V _B	
→ (a)	4	⊕	3
→ (b)	⊕	4	3
→ (c)	1	1	3

1 Graph

$$x_D = 0.99$$

$$x_B = 0.01$$

$$\psi = 0 \Rightarrow \text{Slope} = -\infty$$

$$F = 100 \text{ mol/hr}$$

-1 Units on (For solutions)

-5 Title on graphs (x, y)

-5 For title on graph (x, y hexane/octane graph)

-1 work

answer of 5 mol/hr

Part (a)

R

4 ✓

x_D

0.99

V_B

1 ✓

x_B

0.01

ROP

Slope

Intercept

0.8

0.198

SOP

Slope

Intercept

2 ✓

-0.01

x

0.99

0.17

0.99

0.334

x

0.01

0.175

0.01 ✓

0.34

~~441~~
4
421

z_F

0.17 (from graph) ✓

F

100 moles/hr

from overall and component mole balances ✓

D

16.33 moles/hr ✓

B

83.67 moles/hr ✓

from reflux ratio

L

65.32 moles/hr ✓

mole balance around condenser

V

81.65 moles/hr ✓

from boil-up ratio

V_{bar}

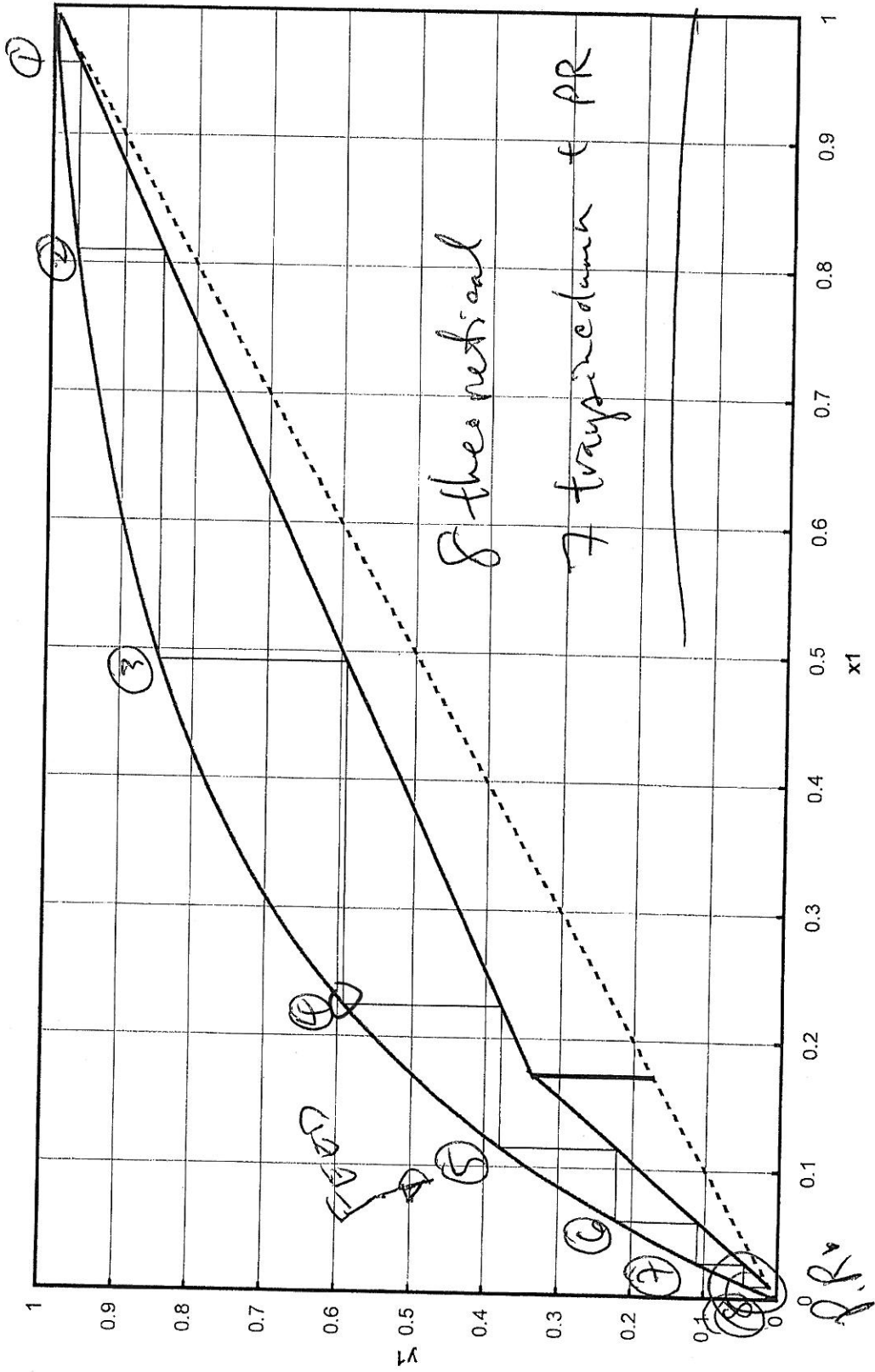
83.67 moles/hr ✓

mole balance around reboiler

L_{bar}

167.34 moles/hr ✓

XY Phase Diagram for Hexane (1) and Octane (2) at 760 torr (part a)



Part (b)

R	1	x_D	0.99
V_B	4	x_B	0.01

ROP
Slope
Intercept

0.5
0.495 ✓

SOP
Slope
Intercept

1.25
-0.0025 ✓

x	y
0.99	0.99
0.66	0.825

x	y
0.01	0.01
0.67	0.835

z_F 0.67 (from graph) ✓

F 100 moles/hr
from overall and component mole balances:
D 67.35 moles/hr
B 32.65 moles/hr

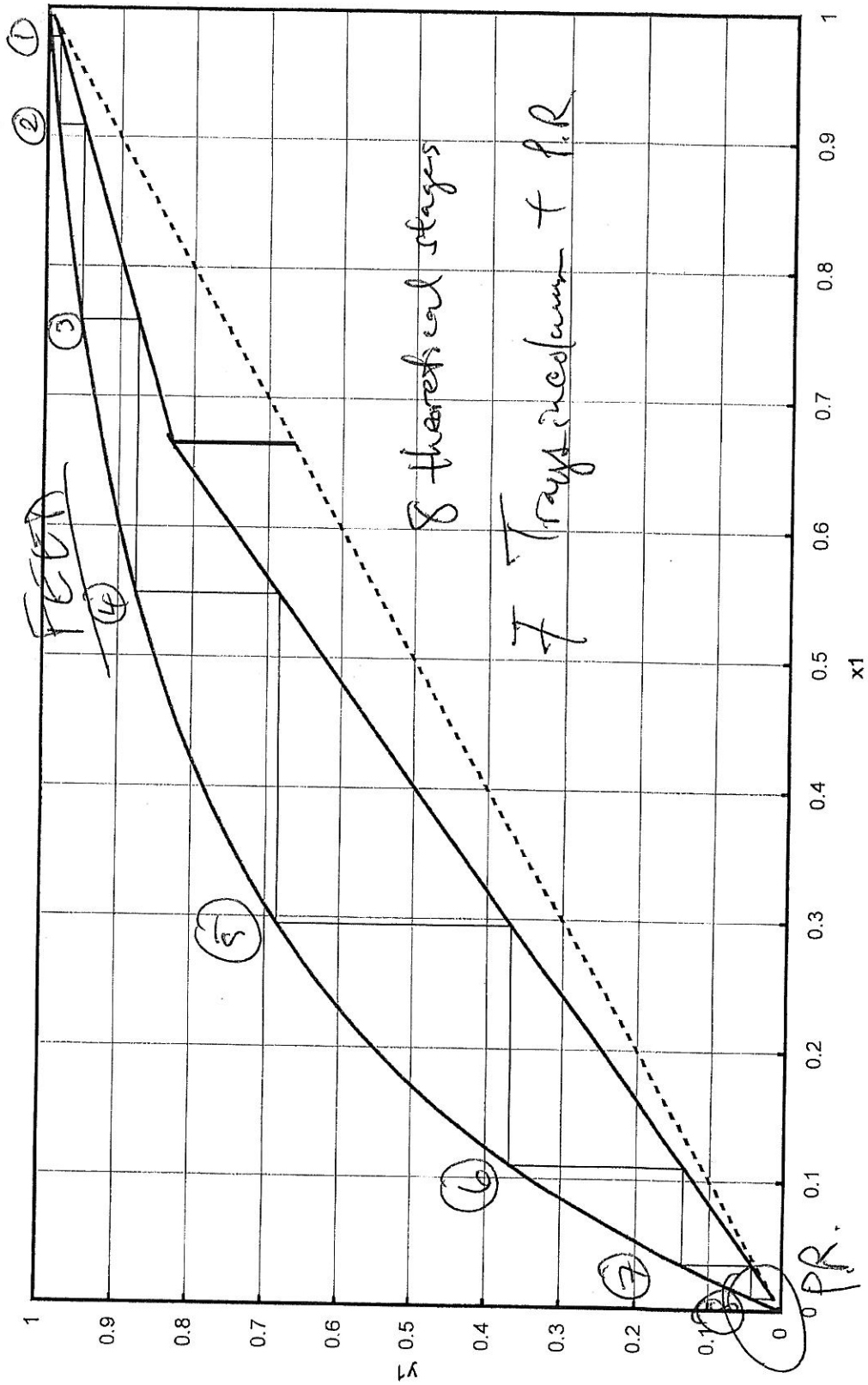
from reflux ratio
L 67.35 moles/hr ✓

mole balance around condenser
V 134.7 moles/hr ✓

from boil-up ratio
 V_{bar} 130.6 moles/hr ✓

mole balance around reboiler
 L_{bar} 163.25 moles/hr ✓

XY Phase Diagram for Hexane (1) and Octane (2) at 760 torr (part b)



Part (c)

R	1	x_D	0.99
V_B	1	x_B	0.01

ROP		SOP	
Slope	0.5	Slope	2
Intercept	0.495	Intercept	-0.01

x	y	x	y
0.99	0.99	0.01	0.01
0.33	0.66	0.34	0.67

z_F 0.33 (from graph) ✓

F 100 moles/hr
from overall and component mole balances:
D 32.65 moles/hr
B 67.35 moles/hr

from reflux ratio
L 32.65 moles/hr

mole balance around condenser
V 65.3 moles/hr

from boil-up ratio
 V_{bar} 67.35 moles/hr

mole balance around reboiler
 L_{bar} 134.7 moles/hr

XY Phase Diagram for Hexane (1) and Octane (2) at 760 torr (part c)

