3. 100 kg of a binary mixture (45 mass percent acetone, 55 mass percent water) is mixed with pure MIK.

(a) If the amount of MIK used is 60 kg, the resulting ternary mixture will split into two phases. What are the masses and compositions of the raffinate and extract phases formed?

(b) What is the minimum amount of MIK required to produce a mixture that separates into two phases.

(c) What is the maximum amount of MIK that can be added such that the resulting mixture still splits into two phases?

Phase diagram is given on separate sheet. Parts (b) and (c) will require a little thought, but you can handle it.

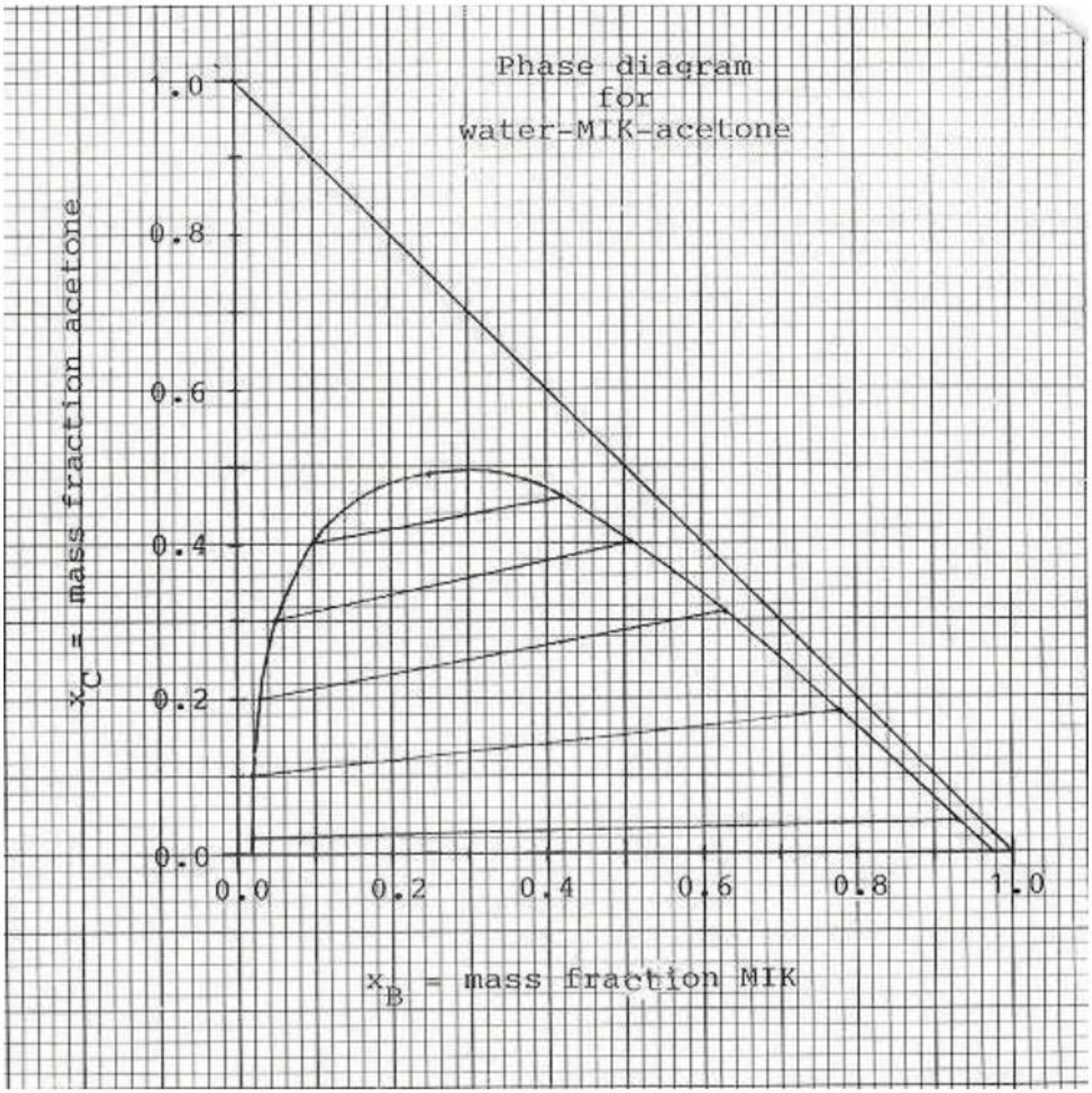
4. 100 kg of a binary mixture of 70 mass % isopropyl ether (A), 30 mass % acetic acid (C) is mixed with pure water (B).

(a) If the amount of water used is 150 kg, what are the amounts and compositions of the raffinate and extract phases formed after equilibium has been reached?

(b) What is the smallest mass of water that must be added to give a separation into two phases at equilibrium?

ether-rich end of tie line		water-rich end of tie line	
x_B	x_C	x_B	x_C
0.01	0.01	0.96	0.03
0.01	0.02	0.92	0.06
0.02	0.05	0.84	0.13
0.04	0.11	0.71	0.26
0.07	0.22	0.59	0.37
0.11	0.31	0.45	0.44
0.15	0.36	0.37	0.46

Phase diagram for problem **3**



PROBLEM 3 A = water, C = acetone, B = MIK

[all parts: mixture of
F : 100 kg, $(x_B)_F = 0$, $(x_C)_F = 0.$
S : $(x_B)_S = 1$, $(x_C)_S = 0$
Connect points representing F + S with straight line. Mixtures will all lie on this line.]

(a) $$(x_C)_M = \frac{F(x_C)_F + S(x_C)_F}{S+F} \quad \text{(C-balance)}$$

$$= \frac{(100)(0.45)+(60)(0)}{160} = 0.281$$

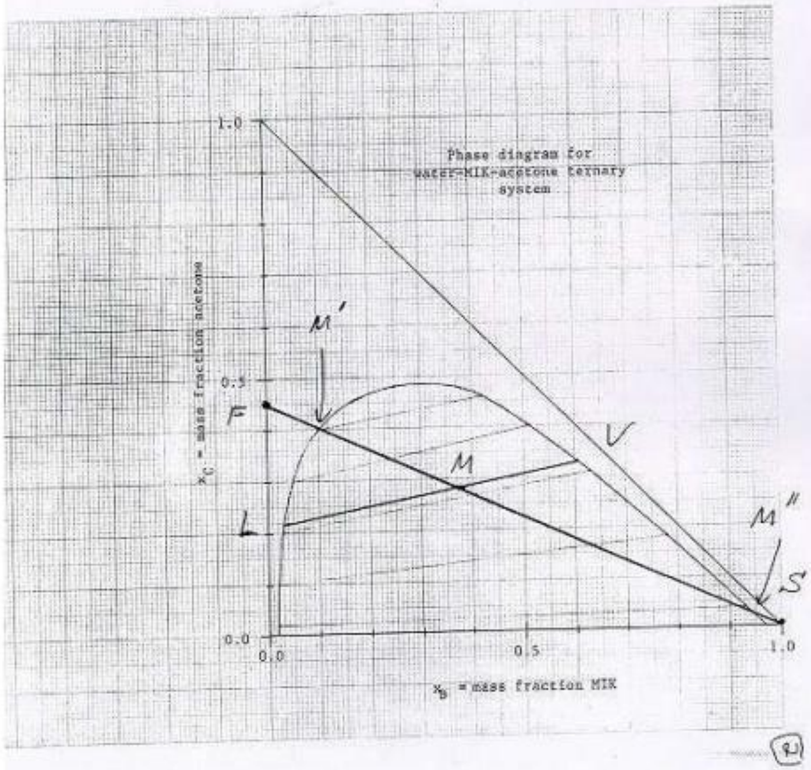
[or $$(x_B)_M = \frac{F(x_B)_F + S(x_B)_F}{S+F} = \quad \text{(B-balance)}$$

$$= \frac{(100)(0) + (60)(1)}{160} = 0.375 \quad]$$

Locate pt. on line where $x_C = 0.281$ [OR locate pt. with $x_B = 0.375$, $x_C = 0.281$.]

Mixture splits into two phases; call them L and V.

L-phase	V-phase
$x_B = 0.030$	$y_B = 0.607$
$x_C = 0.215$	$y_C = 0.328$
$(x_A = 0.755)$	$(y_A = 0.065)$



By C-balance, say,

$$(L+V)(x_c)_M = L x_c + V y_c$$

$$L[(x_c)_M - x_c] = V(y_c - (x_c)_M]$$

$$\frac{L}{V} = \frac{y_c - (x_c)_M}{(x_c)_M - x_c} = \frac{0.328 - 0.281}{0.281 - 0.215} = 0.71$$

[or by B-balance $\frac{L}{V} = \frac{y_B - (x_B)_M}{(x_B)_M - x_B} = \frac{0.507 - 0.375}{0.375 - 0.020} = 0.67$]

Looks like $\frac{L}{V} \approx 0.69$

Then $L + V = V(\frac{L}{V} + 1) = 160$ kg

$\Rightarrow$ $V = 95$ kg, $L = 65$ kg

(d) Minimum MIK to form two phases $\Rightarrow$ just get inside two-phase region along line segment $\overline{FS}$. Coordinates $(x_B)_{M'} = 0.102$, $(x_C)_{M'} = 0.401$.

e.g. by C-balance

$$F(x_c)_F + S(x_c)_S = (F+S)(x_c)_{M'}$$

or

$$S = \frac{(x_c)_{M'} - (x_c)_F}{(x_c)_S - (x_c)_{M'}} \cdot F = \frac{0.401 - 0.45}{0 - 0.401} \cdot 100\text{ kg}$$

$S = 12$ kg

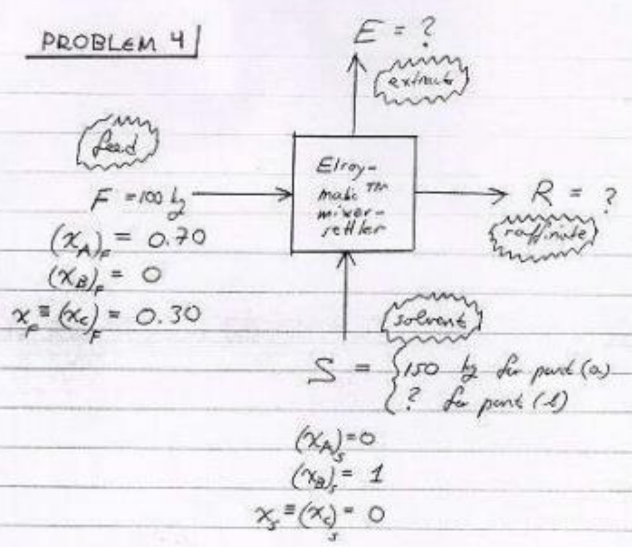
(c) Maximum MIK & still form two phases ⇒ just pass out of two-phase region along $\overline{FS}$.

$$S = \frac{(x_C)_{M''} - (x_C)_F}{(x_C)_S - (x_C)_{M''}} \cdot F = \frac{0.026 - 0.45}{0 - 0.026} \cdot 100\ kg$$

(0.026)

$$\boxed{S = 1.6 \times 10^3\ kg}$$

PROBLEM 4



(a) Mixture

$$\begin{cases} M = F + S = 250\ kg & \text{(total mass)} \\ M x_M = F x_F + S x_S & \text{(component C)} \end{cases}$$

$$\Rightarrow \quad x_M = \frac{(100)(0.30) + (150)(0)}{250} = 0.120$$

Find pt. on line segment joining composition of feed & solvent streams where $x \equiv x_C = 0.120$. This represents overall composition of mixture.

(!) → BUT mixture does not exist as one phase with this composition since pt. for M lies inside the two-phase region. Rather, it splits into two immiscible phases. Interpolate tie line through the point M. Conclude that the two phases have the following compositions:

raffinate	extract
$(x_B)_R = 0.020$	$(x_B)_E = 0.825$
$x_R \equiv (x_C)_R = 0.060$	$x_E = (x_C)_E = 0.145$
$\therefore\ (x_A)_R = 0.920$	$\therefore\ (x_A)_E = 0.030$

answer (a)

To determine the amounts of these two phases,† consider total mass and C balance:

$$\begin{cases} R + E = M & \text{(total mass)} \\ R x_R + E x_E = M x_M & \text{(component C)} \end{cases}$$

$M = 250$ kg; $x_R = 0.060$, $x_E = 0.145$, $M = 250$ kg, $x_M = 0.120$

Two eqs. in two unknowns R and E. Solve ⇒

$$R = 73.5 \text{ kg} \quad \text{and} \quad E = 176.5 \text{ kg}$$

† Can consider M as mixture of F and S or as mixture of R and E ← SUPER GROOVY WOW!

(b) When mixture just barely splits into two immiscible phases, mixture pt. M lies at boundary of two-phase region (and pt. M also lies on straight line joining pts. for F and S). From graph, read off

$$x_M \equiv (x_c)_M = 0.27 \quad \text{to just barely get split into two phases.}$$

As usual, consider total mass and C balance:

$$\begin{cases} F + S = M \\ F x_F + S x_S = M x_M \end{cases}$$

$F = 100$ kg; $x_F = 0.30$, $x_S = 0$, $x_M = 0.272$

From 2nd eq.,

$$(100)(0.30) + 0 = (M)(0.272)$$

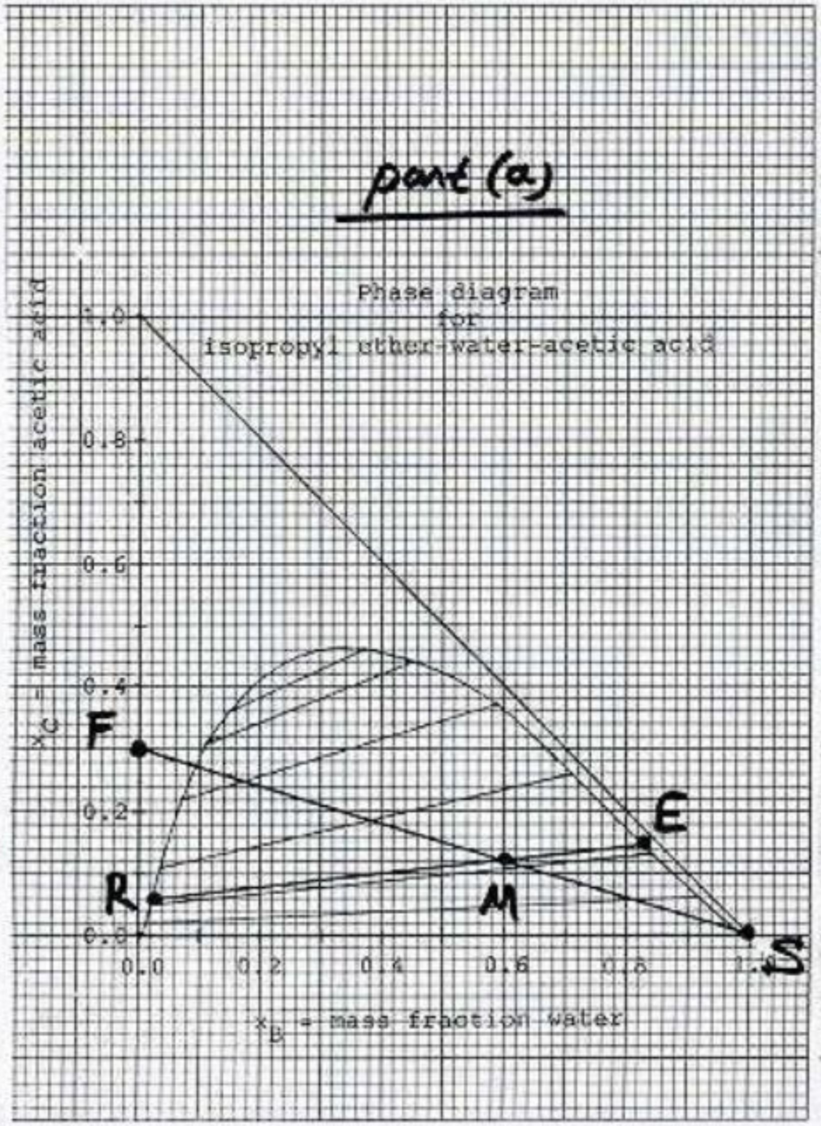
or $M = 110.3$ kg

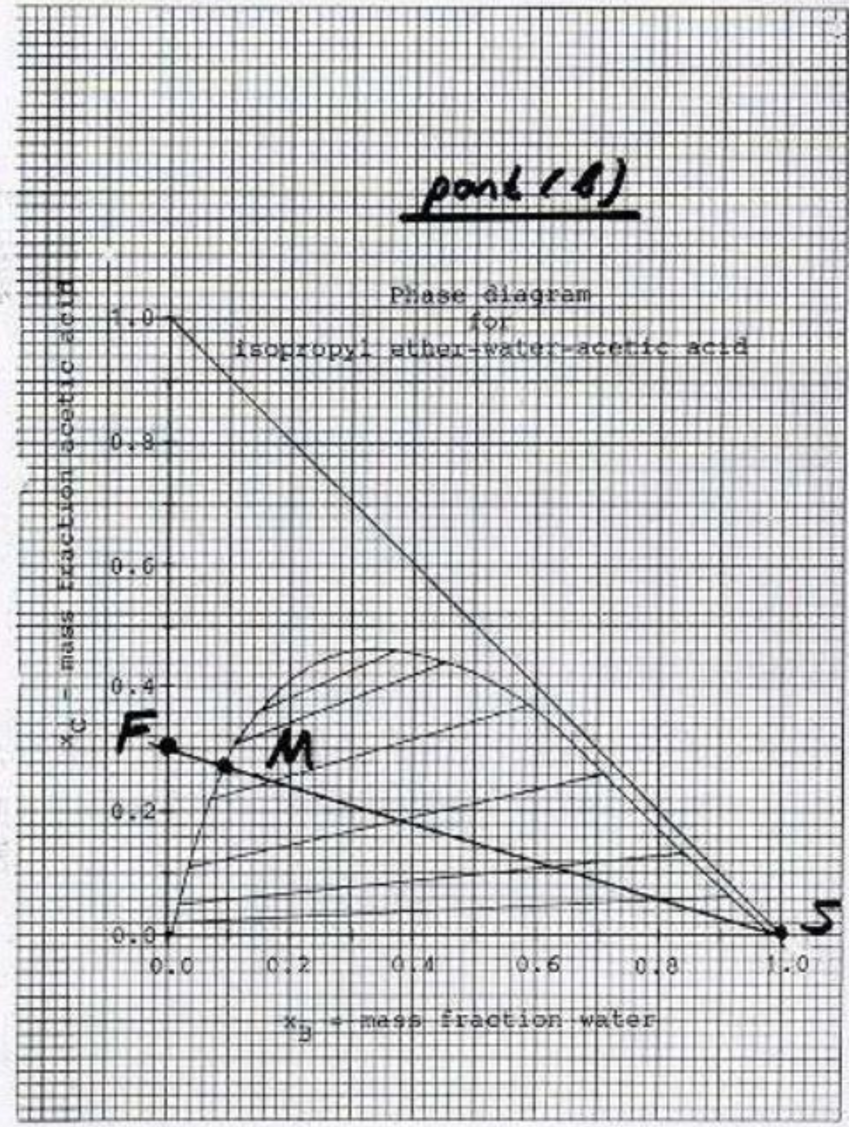
Then from 1st eq.,

$$S = M - F = 110.3 - 100 = 10.3 \text{ kg}$$

$$= 10.3 \text{ kg}$$

answer (b)


part (a)
Phase diagram
for
isopropyl ether-water-acetic acid
x_C = mass fraction acetic acid
x_B = mass fraction water
0.0
0.2
0.4
0.6
0.8
1.0
F
E
R
M
S


part (b)
Phase diagram
for
isopropyl ether-water-acetic acid
x_C = mass fraction acetic acid
x_B = mass fraction water
0.0
0.2
0.4
0.6
0.8
1.0
F
M
S