Separation Process

Distillation Problems

1.

A distillation column is used to separate 100 mol/h of a mixture made of two compounds A and C. The feed mixture consists of equal parts of saturated vapor and liquid, with a molar composition of 35% A. It is intended to obtain a distillate with a molar composition of 93% A and a residue with a molar composition of 97.8% C. The reflux ratio is equal to 4.

a) How many equilibrium stages are needed in each section of the column?

b) What is the optimal plate for the feed inlet?

c) Determine the minimum reflux ratio (Rmin).

d) Determine the minimum number of theoretical plates required (Nmin).

(e) Calculate the slope of the operating line of the feed for the following physical conditions of the feed:

i) Saturated liquid

(ii) Saturated vapour

(iii) superheated vapour, passing two moles of liquid to the vapour for every 10 moles of feed

(iv) The feed enters at 290 K, with a specific heat of 1.7 kJ/kg.K, a boiling point of 336 K and a latent heat of vaporization of 25 900 J/mol

f) Calculate the heat involved in the boiler and in the condenser

2.

It is intended to design a distillation column to operate continuously. The column will be used to separate a mixture containing 15.67% CS_2 and 84.3% CCl_4, to give a distillate with 91% CS_2 and a residue with 97.3% CCl_4 (all percentages are by weight). Assume a reflux of 3.16 and a total efficiency of 70%. The feed enters at 290 K, having a specific heat of 1.7 kJ/kg.K, a boiling point of 336 K and a latent heat of vaporization of 25 900 J/mol. Determine the number of actual stages of the column.

$M(CS_2)$ = 76 g/mol), $M(CCl_4)$ = 154 g/mol

3.

It is intended to separate a mixture of benzene and toluene, which contains 40% benzene, to give a distillate with 90% in benzene and a residue with 10% in benzene. The feed is heated to the boiling temperature before entering the column. The column is operated with a reflux ratio of 2.2 times greater than the minimum.

a) Determine the number of theoretical plates required.

b) What is the optimal stage for the feed inlet?

4.

It is intended to distillate a batch of a methanol / water mixture having a molar percentage of methanol equal to 49%. The boiler is charged with 200 moles of the mixture and the distillation column has 3 theoretical plates and a total condenser. The system is operated with a constant reflux ratio equal to 0.64. At the end of the process, it remains in the boiler 106.6 moles of residue with a composition of 18 mol% in methanol. Calculate:

(a) the composition of the distillate obtained at the beginning

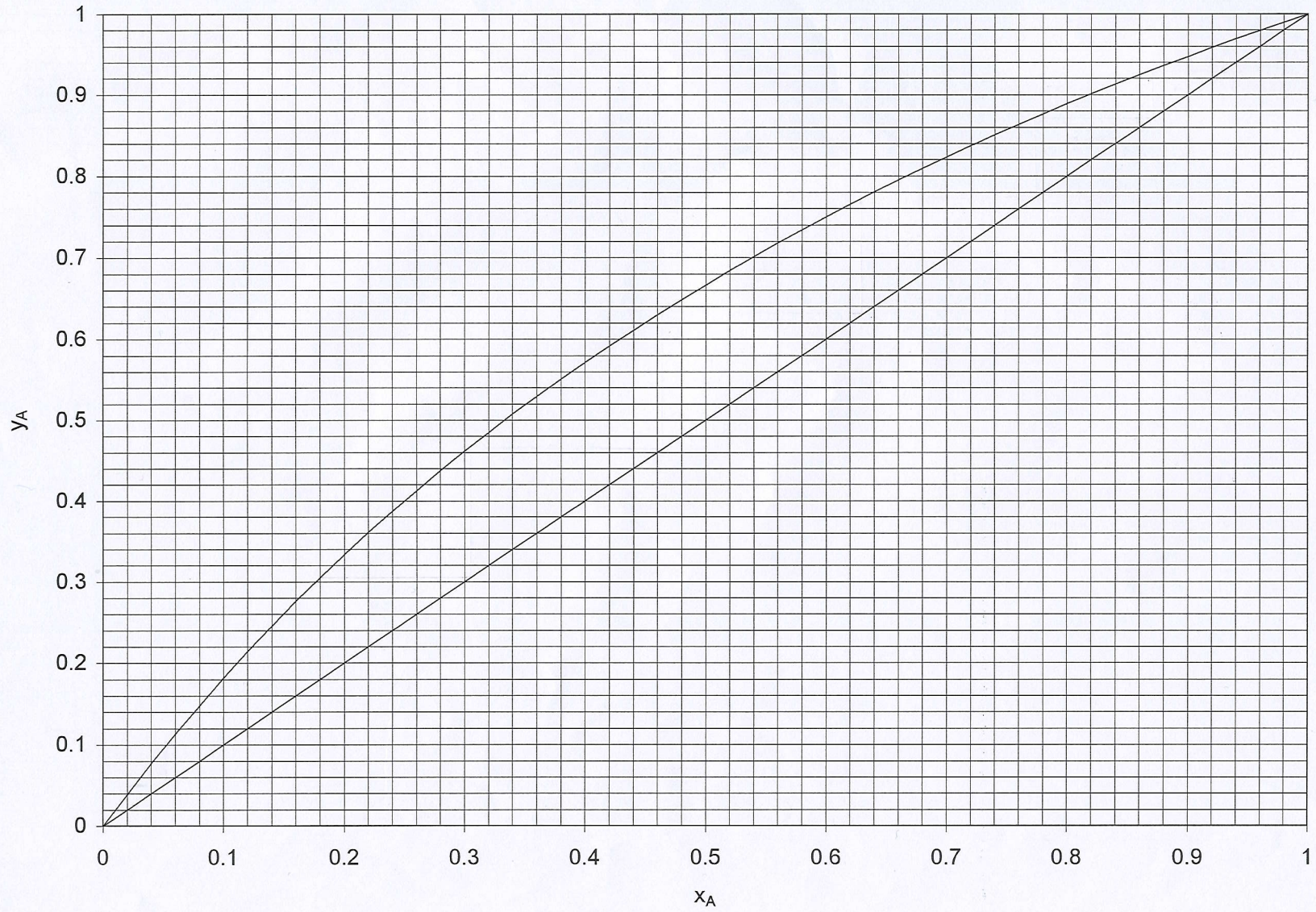
b) The composition of the distillate at the end of the process

(c) the average composition of the distillate obtained during the process.

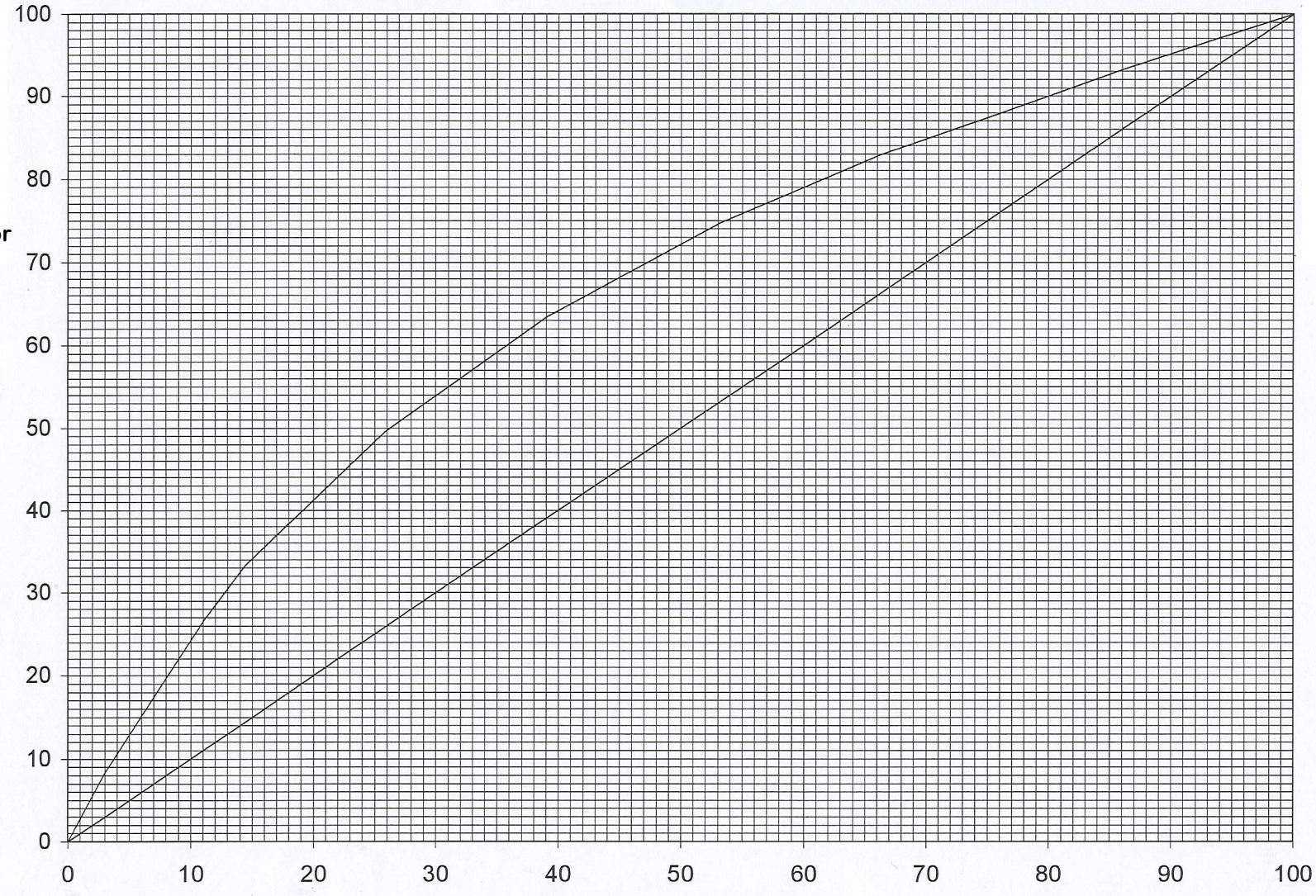
5.

Considering the previous problem, now assume that the column will be operated by varying the reflux ratio (from $R_{inicial} = 0.64$ to $R_{final} = 3.2$) to obtain a constant distillate composition ($x_D = 0.9$). Determine the final composition of the residue and the amount of distillate obtained in these conditions.

Equilibrium diagram for system A + C



Equilibrium diagram for system CS2 + CCl4



% molar de CS2 no vapor

% molar de CS2 no líquido

Diagrama de equilíbrio para os componentes benzeno e tolueno

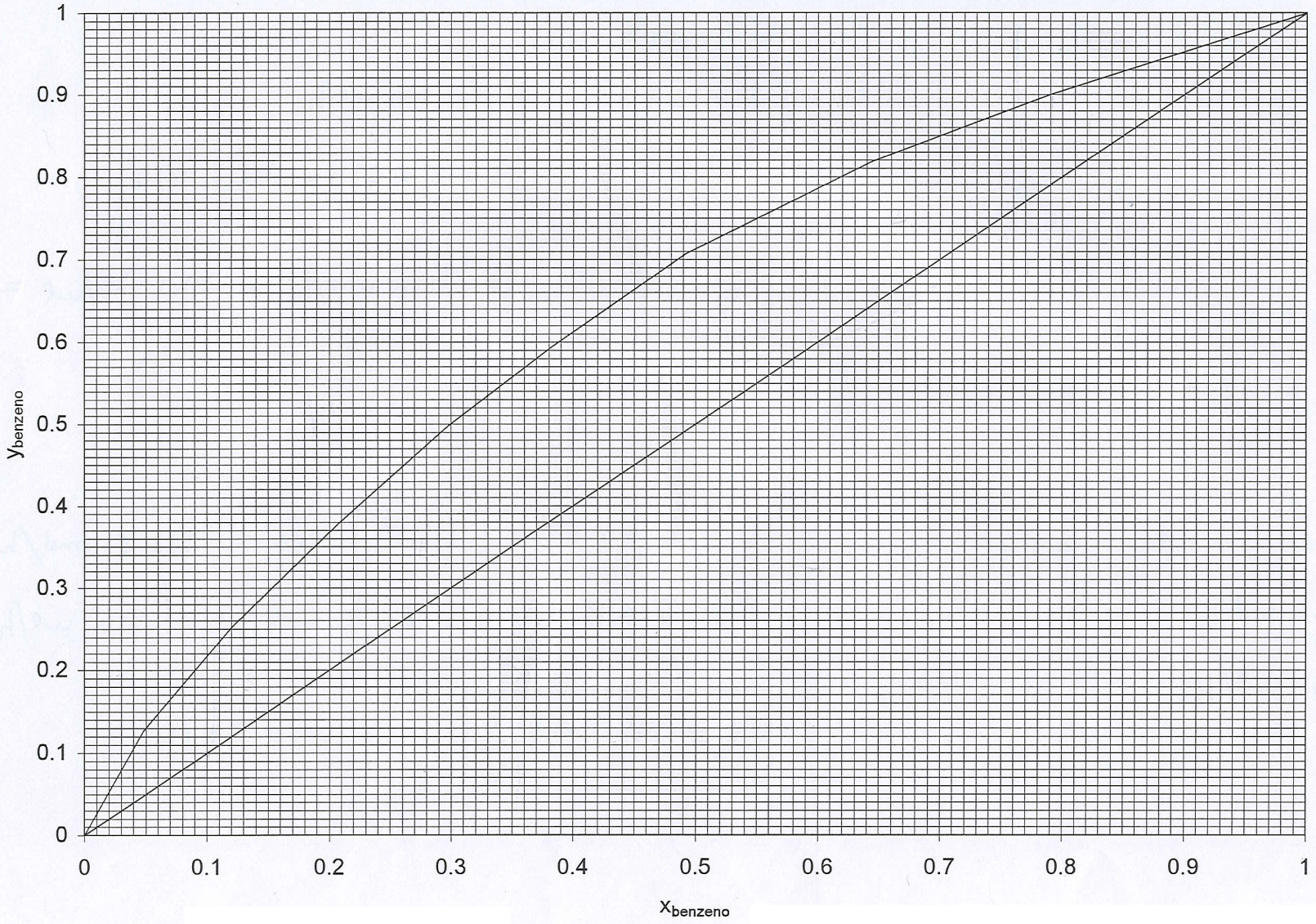


Diagrama de equilíbrio
Sistema metanol/água