Gas Absorption

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Processos de Separação

Gas Absorption

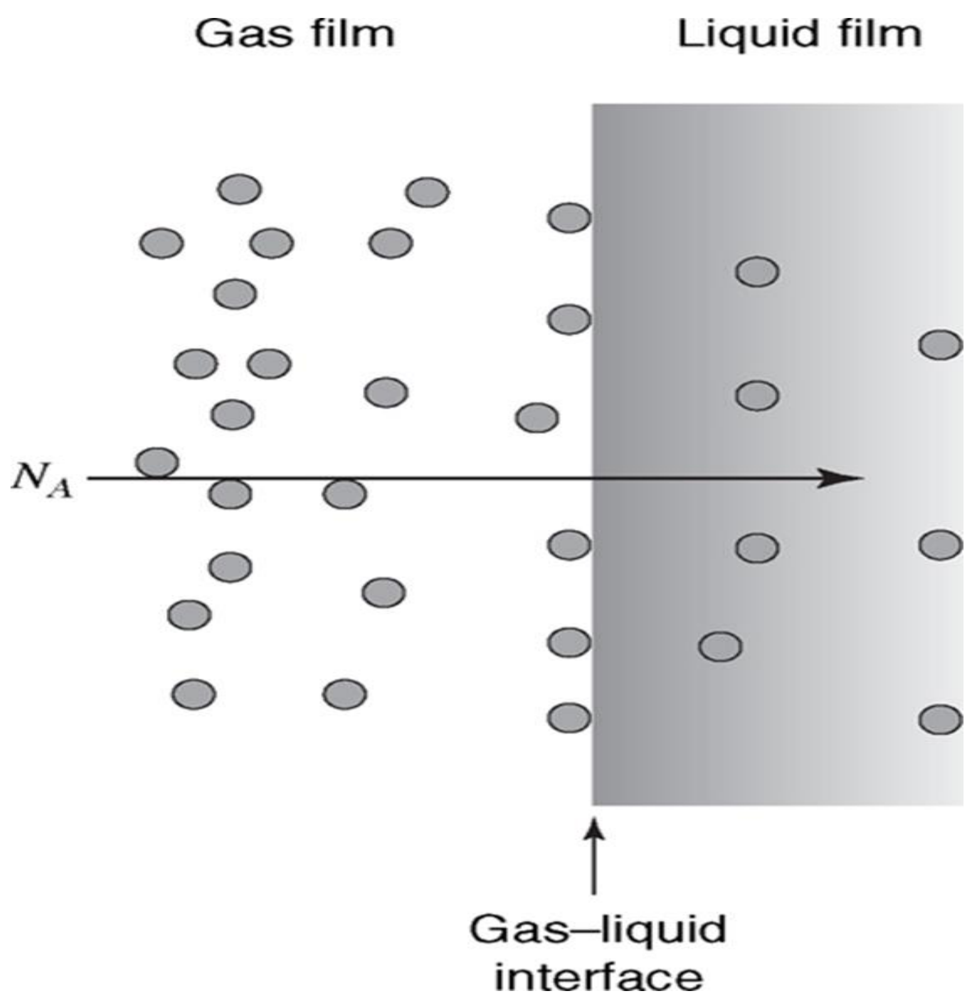
Absorption – between gas and liquid.

Solutes are absorbed from the gas phase into the liquid phase.

Absorption does not destroy the gases.

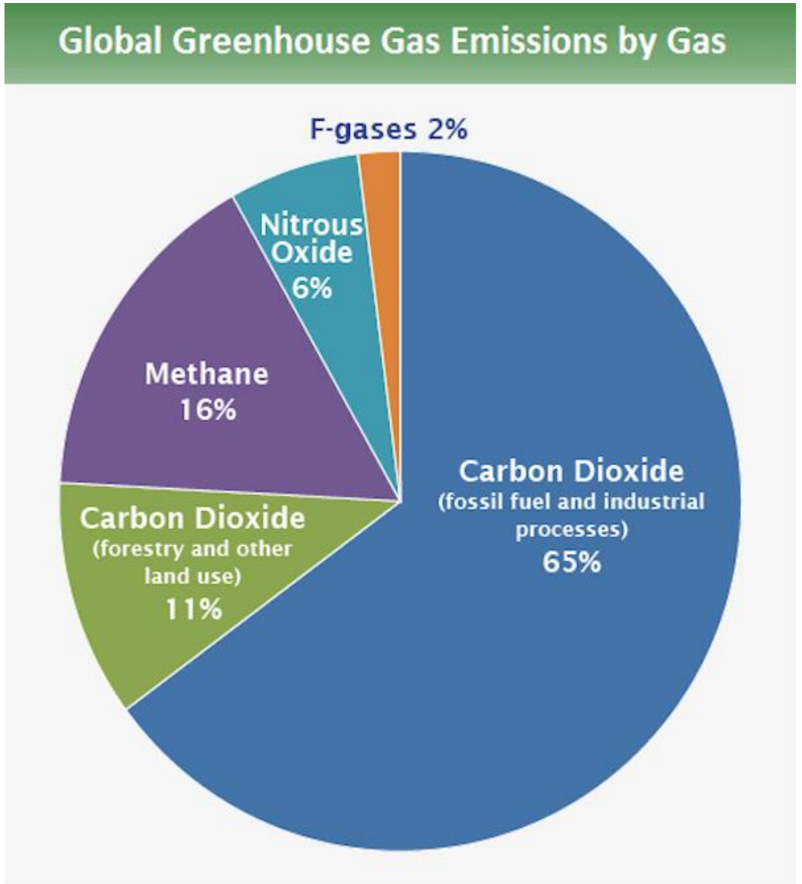
It simply transfers the gas to the liquid.

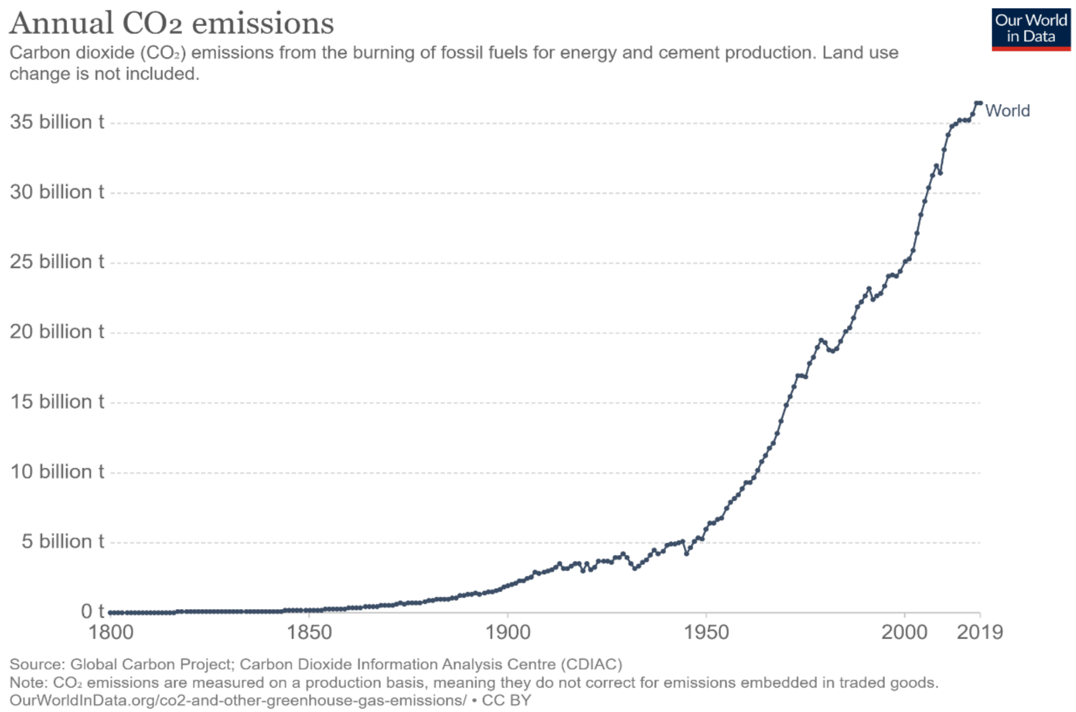
Stripping - reverse of absorption

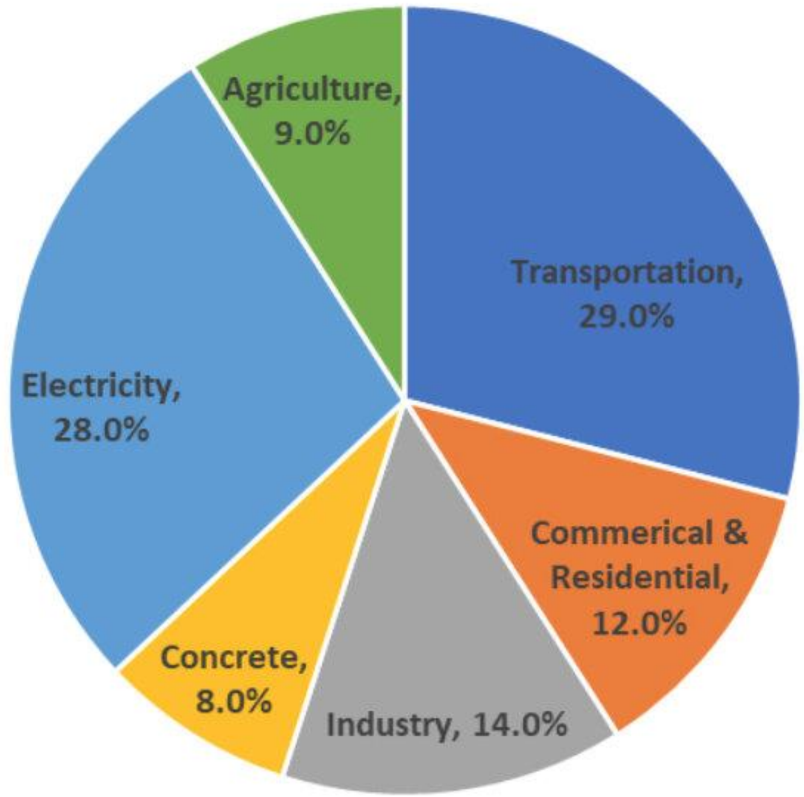


CO_2

76% global warming




Annual CO2 emissions
Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.
Our World in Data
35 billion t
30 billion t
25 billion t
20 billion t
15 billion t
10 billion t
5 billion t
0 t
1800
1850
1900
1950
2000
2019
World
Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre (CDIAC)
Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY


Agriculture, 9.0%
Transportation, 29.0%
Electricity, 28.0%
Commerical & Residential, 12.0%
Concrete, 8.0%
Industry, 14.0%

Gas Absorption

Physical Absorption

NH_3

Chemical Absorption

$$SO_2 + 2\,NaOH \longrightarrow Na_2SO_3 + H_2O$$

Gas Absorption

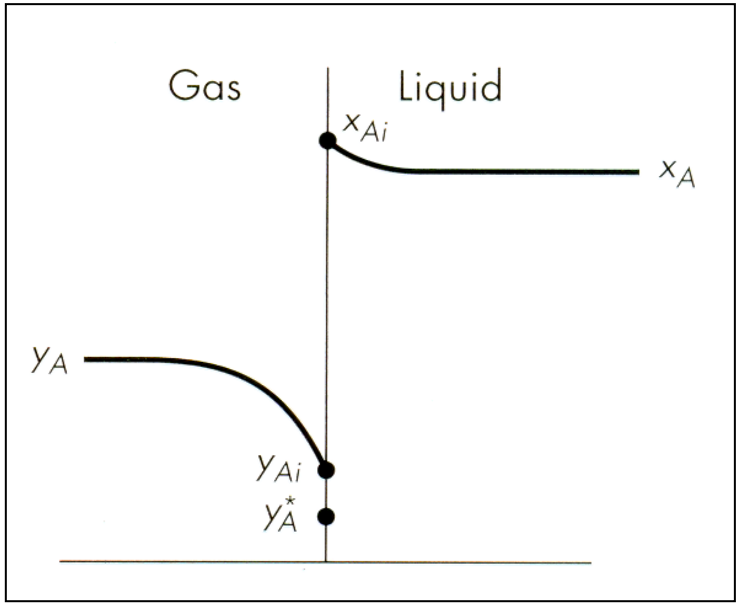
- The rate of absorption, r per unit volume of packed column is given by any of the following equations:

$$r = k_y a(y - y_i) \tag{18.7}$$

$$r = k_x a(x_i - x) \tag{18.8}$$

$$r = K_y a(y - y^*) \tag{18.9}$$

$$r = K_x a(x^* - x) \tag{18.10}$$



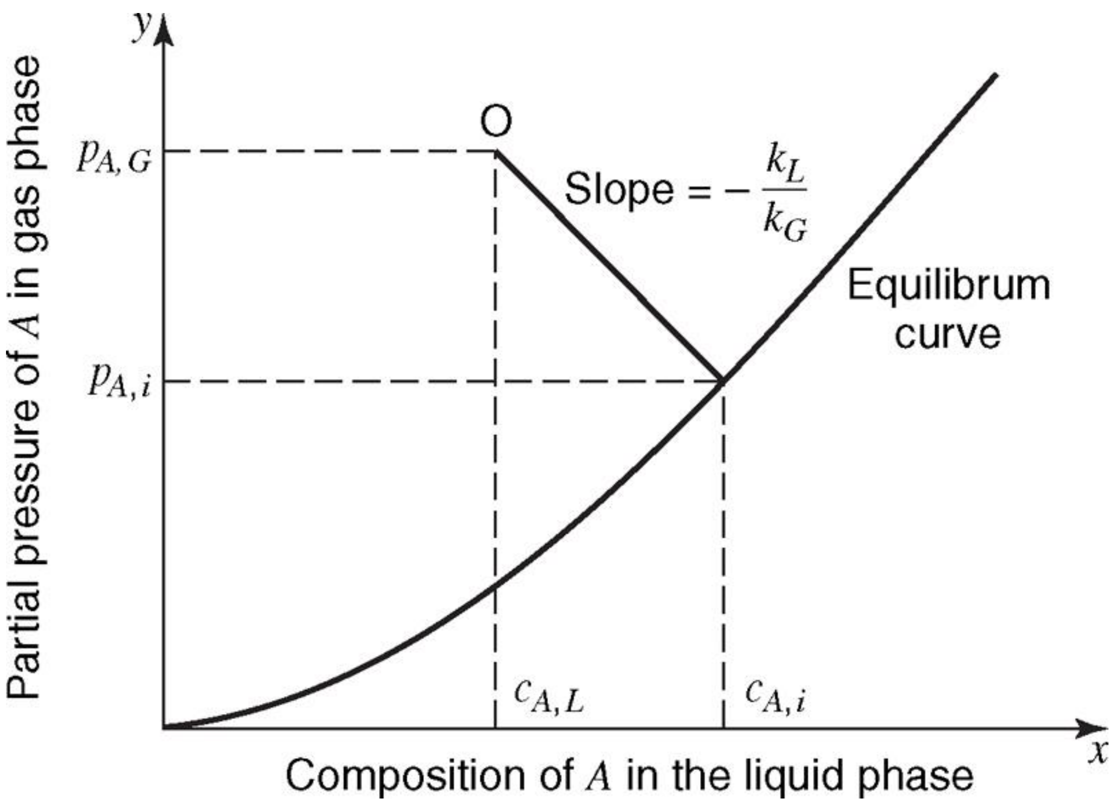
where y and x refer to the mole fraction of the component being absorbed.

Gas Absorption

$$N_{A,z} = k_G \left(p_{A,g} - p_{A,i} \right)$$

$$N_{A,z} = k_L \left(c_{A,i} - c_{A,L} \right)$$

$$-\frac{k_L}{k_G} = \frac{p_{A,G} - p_{A,i}}{c_{A,L} - c_{A,i}}$$



- The overall coefficient:

$$\frac{1}{K_y a} = \frac{1}{k_y a} + \frac{m}{k_x a} \qquad (18.12)$$

$$\frac{1}{K_x a} = \frac{1}{k_x a} + \frac{1}{m k_y a} \qquad (18.13)$$

- Where *m* is the local slope of the equilibrium curve.
- In Eq. (18.12),

$\frac{1}{k_y a}$ = the resistance of mass transfer in the gas film.

$\frac{m}{k_x a}$ = the resistance of mass transfer in the liquid film

Gas-liquid equilibrium

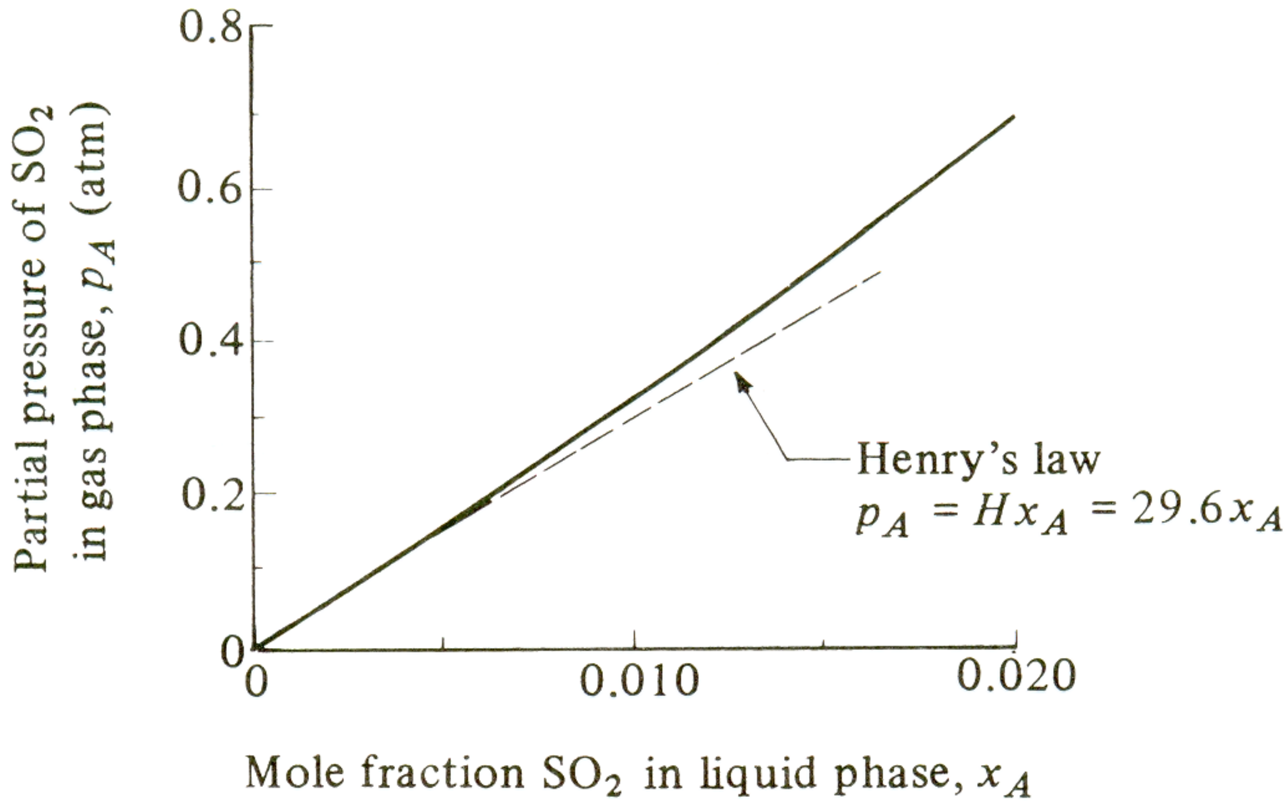


FIGURE 10.2-1. *Equilibrium plot for SO_2–water system at 293 K (20°C).*

Gas-liquid equilibrium

A.3-20 Equilibrium Data for Methanol–Water System

Mole Fraction Methanol in Liquid, x_A	*Partial Pressure of Methanol in Vapor, p_A (mm Hg)*	
	39.9°C (313.1 K)	*59.4°C (332.6 K)*
0	0	0
0.05	25.0	50
0.10	46.0	102
0.15	66.5	151

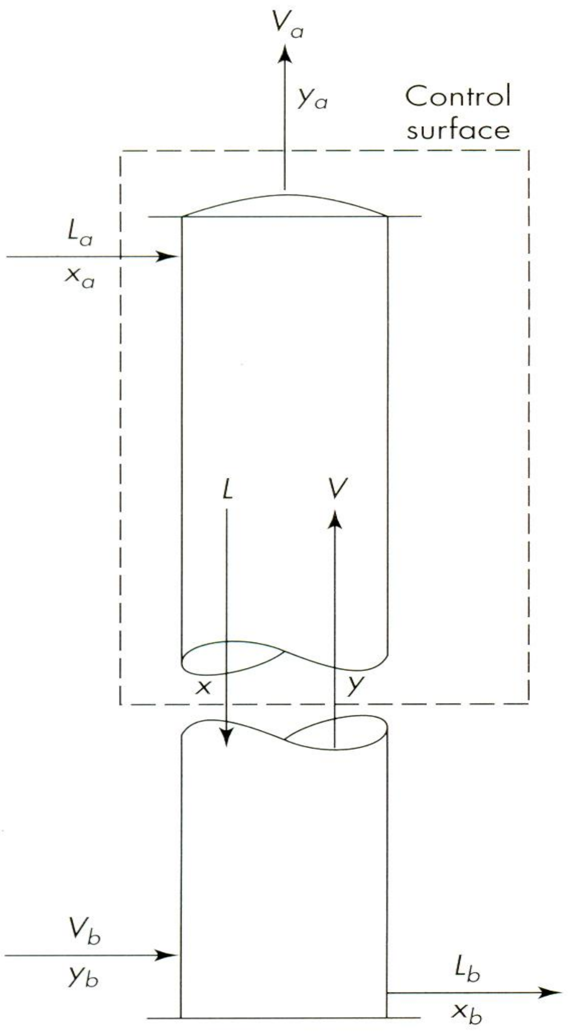
Source: National Research Council, *International Critical Tables*, Vol. III. New York: McGraw-Hill Book Company, 1929.

Gas Absorption

$$\boxed{\frac{1}{K_G} = \frac{\left(p_{A,G} - p_{A,i}\right)}{N_{A,z}} + \frac{m\left(c_{A,i} - c_{A,L}\right)}{N_{A,z}}}$$

$$\boxed{\frac{1}{K_G} = \frac{1}{k_G} + \frac{m}{k_L}}$$

Absorption column



L = molar flow rate of the liquid phase

V = molar flow rate of the gas phase

x = liquid phase concentration

y = gas phase concentration

FIGURE 18.9
Material-balance diagram for packed column.

Material balances for the portion of the column above an arbitrary section (dashed line)

- Total material balance:

$$L_a + V = L + V_a \tag{18.2}$$

- Material balance on component A

$$L_a x_a + V y = L x + V_a y_a \tag{18.3}$$

Overall material equations

- Total material balance:

$$L_a + V_b = L_b + V_a \tag{18.4}$$

- Material balance on component A:

$$L_a x_a + V_b y_b = L_b x_b + V_a y_a \tag{18.5}$$

Gas Absorption

- Rearranging Eq. (18.3) gives operating-line equation:

$$y = \frac{L}{V}x + \frac{V_a y_a - L_a x_a}{V} \tag{18.6}$$

- The operating line can be plotted on an arithmetic graph along with the equilibrium curve as shown in Fig. 18.10.

- The operating line must lie above the equilibrium line for absorption to take place.

Gas Absorption- minimum flowrate

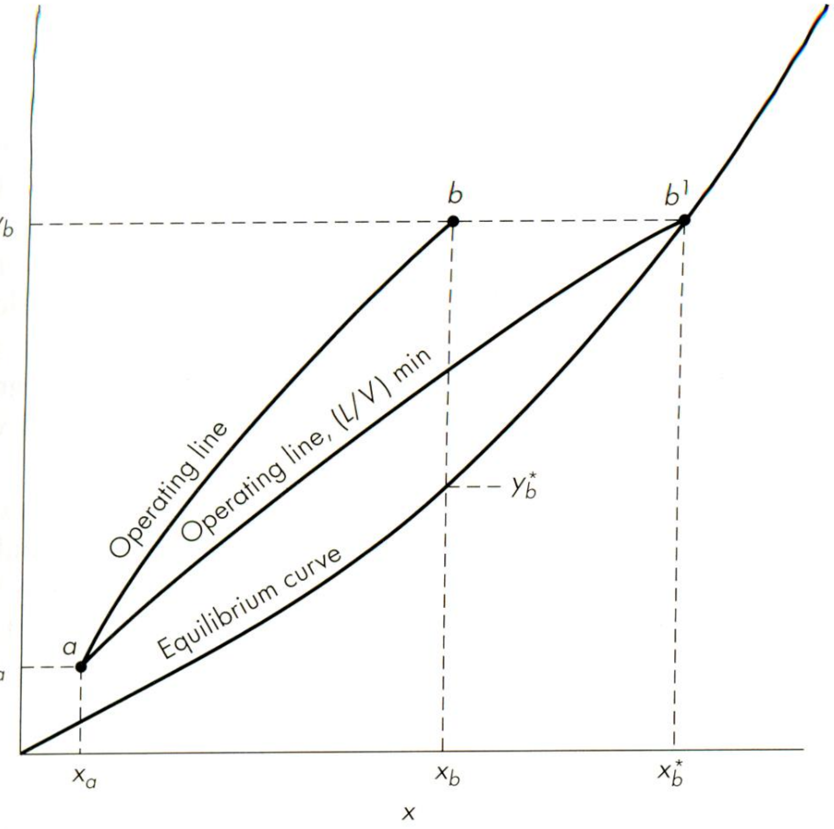
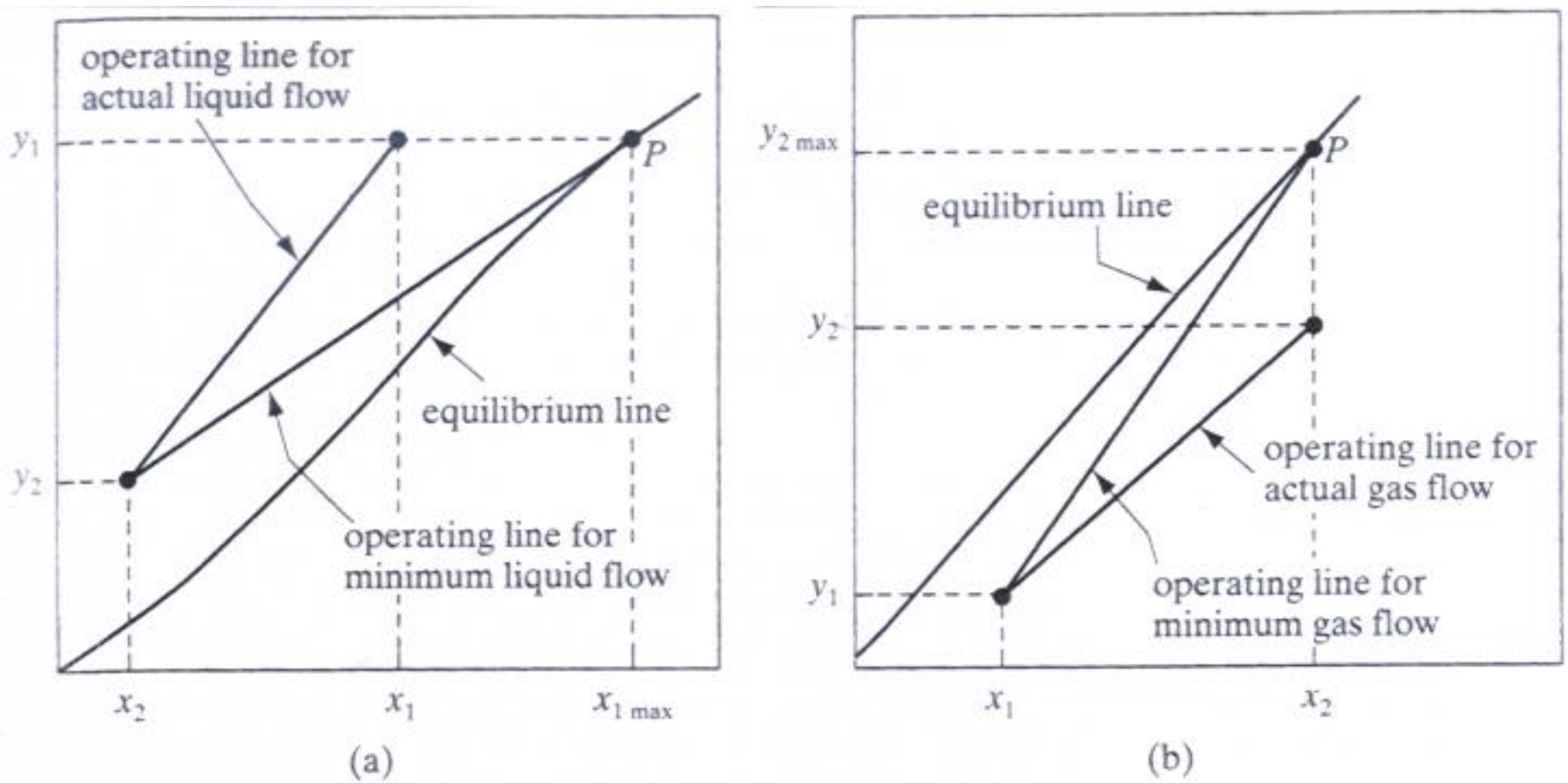


FIGURE 18.10
Limiting gas-liquid ratio.

Gas Absorption- minimum flowrate



Operating line for limiting conditions: (a) absorption, (b) stripping.

It is proposed to absorb 50 % of acetone present in air. The water at the inlet of the column has no acetone and air (1 atm, 20˚C) contains 1% acetone. The molar flowrates of water and air are 65 mol/s e 24 mol/s, respectively. The equilibrium is described Raoult's law ($p_A=P_A^* x_A$) with $P_A^*=2$ atm). If absorption column is operated in **countercurrent mode** with water on the top, calculate:

a) The driving force on the top and on the basis of the column
b) The minimum water flow rate.

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a) The driving force on the top and on the basis of the column
b) The minimum water flow rate.

- Operation in countercurrent
- Lmin=24mol/s

- Operation em cocurrent
- Lmin=48mol/s

- Why?