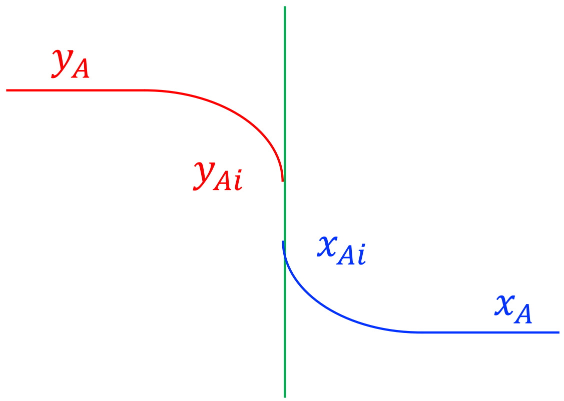
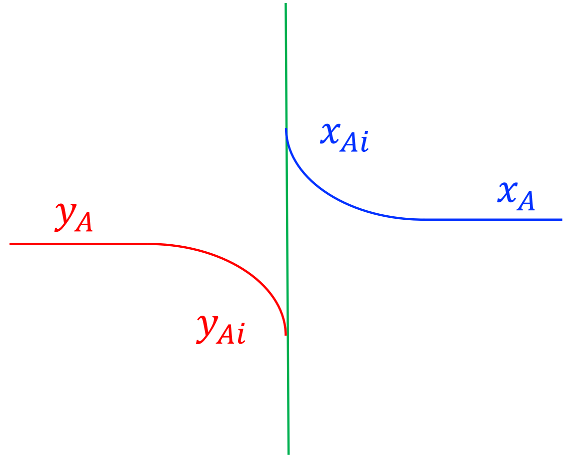
17.4 Mass transfer between phases

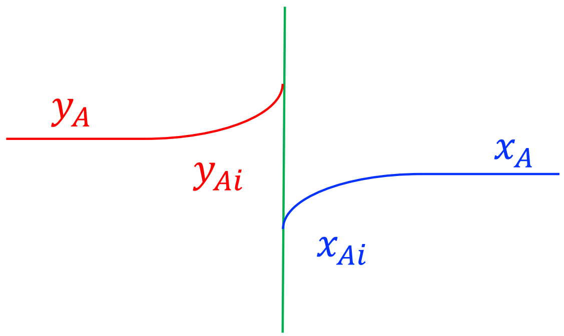
i) Two film theory

[Gas absorption]





[Distillation]



<u>Gas phase</u>

- $N_A = k_y(y_A - y_{Ai})$

<u>Liquid phase</u>

- $N_A = k_x(x_{Ai} - x_A)$

k_y: individual mass transfer coefficient in gas phase
k_x: individual mass transfer coefficient in liquid phase

17.4 Mass transfer between phases

i) Two film theory

Gas phase

- $N_A = k_y(y_A - y_{Ai})$

k_y: individual mass transfer coefficient in gas phase
k_x: individual mass transfer coefficient in liquid phase

Gas phase

- $N_A = k_x(x_{Ai} - x_A)$

Overall phase

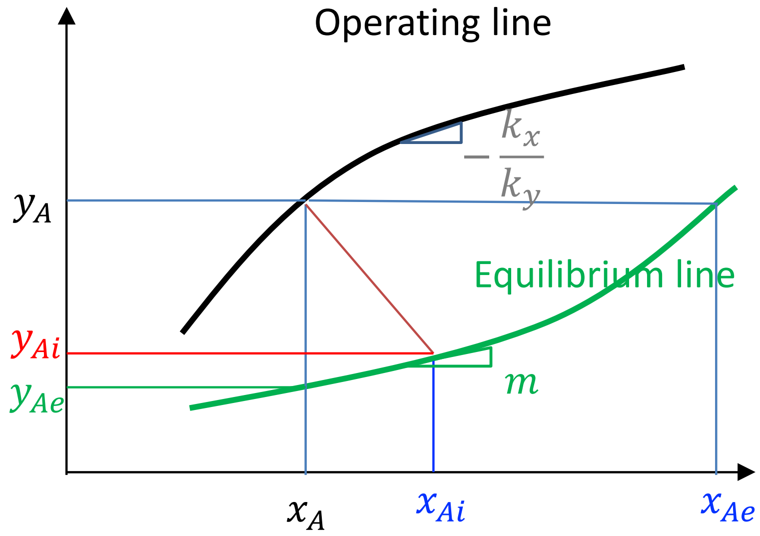
- ~~$N_A = K(y_A - x_A)$~~

- $N_A = K_y(y_A - y_{Ae})$
- $N_A = K_x(x_{Ae} - x_A)$

K_y: overall mass transfer coefficient in gas phase
K_x: overall mass transfer coefficient in liquid phase

$y_A - y_{Ae}$: overall driving force in gas phase
$x_{Ae} - x_A$: overall driving force in liquid phase

17.4 Mass transfer between phases



$$N_A = k_y(y_A - y_{Ai}) = \frac{(y_A - y_{Ai})}{\frac{1}{k_y}}$$

$$N_A = k_x(x_{Ai} - x_A) = \frac{(x_{Ai} - x_A)}{\frac{1}{k_x}}$$

$$N_A = K_y(y_A - y_{Ae}) = \frac{(y_A - y_{Ae})}{\frac{1}{K_y}}$$

$$N_A = K_x(x_{Ae} - x_A) = \frac{(x_{Ae} - x_A)}{\frac{1}{K_x}}$$

$$k_y(y_A - y_{Ai}) = k_x(x_{Ai} - x_A)$$

$$\text{Slope} = \frac{y_A - y_{Ai}}{x_{Ai} - x_A} = -\frac{y_{Ai} - y_A}{x_{Ai} - x_A} = -\frac{k_x}{k_y}$$

17.4 Mass transfer between phases

ii) Equilibrium relation

Assume equilibrium line is linear (narrow area)

then $y_A = m \cdot x_A + C$

$$y_{Ai} = m \cdot x_{Ai} + C$$
$$y_A = m \cdot x_{Ae} + C$$
$$y_{Ae} = m \cdot x_A + C$$

17.4 Mass transfer between phases

iii) Relation between overall m.t.c. & individual m.t.c.

$$y_{Ai} = m \cdot x_{Ai} + C$$
$$y_A = m \cdot x_{Ae} + C$$
$$y_{Ae} = m \cdot x_A + C$$

① For K_y, k_y, and k_x

- $N_A = \frac{y_A - y_{Ai}}{\frac{1}{k_y}} = \frac{(m \cdot x_{Ai} + C) - (m \cdot x_A + C)}{\frac{m}{k_x}} = \frac{y_{Ai} - y_{Ae}}{\frac{m}{k_x}} = \frac{(y_A - y_{Ae})}{\frac{1}{K_y}}$
- $N_A = \frac{y_A - y_{Ae}}{\frac{1}{K_y}} \Rightarrow \frac{1}{K_y} = \frac{y_A - y_{Ai}}{N_A} + \frac{y_A - y_{Ae}}{N_A} = \frac{y_A - y_{Ai}}{k_y(y_A - y_{Ai})} + \frac{y_A - y_{Ae}}{\frac{y_{Ai} - y_{Ae}}{\frac{m}{k_x}}}$

$$\boxed{\frac{1}{K_y} = \frac{1}{k_y} + \frac{m}{k_x}}$$

17.4 Mass transfer between phases

iii) Relation between overall m.t.c. & individual m.t.c.

$y_{Ai} = m \cdot x_{Ai} + C$
$y_A = m \cdot x_{Ae} + C$
$y_{Ae} = m \cdot x_A + C$

② For K_y, and K_x

- $N_A = \frac{y_A - y_{Ae}}{\frac{1}{K_y}} = \frac{x_{Ae} - x_A}{\frac{1}{K_x}} \frac{m}{m} = \frac{m \cdot x_{Ae} + C - m \cdot x_A - C}{\frac{m}{K_x}} = \frac{y_A - y_{Ae}}{\frac{m}{K_x}}$
- $N_A = \frac{y_A - y_{Ae}}{\frac{1}{K_y}} = \frac{y_A - y_{Ae}}{\frac{m}{K_x}}$

$$\frac{1}{K_y} = \frac{m}{K_x}$$

17.4 Mass transfer between phases

iii) Relation between overall m.t.c. & individual m.t.c.

③ For K_x, k_x, and k_x

- $\frac{m}{K_x} = \frac{1}{K_y}\left(= \frac{1}{k_y} + \frac{m}{k_x}\right)$
- $\frac{m}{K_x} = \frac{1}{k_y} + \frac{m}{k_x}$

$$\boxed{\frac{1}{K_x} = \frac{1}{m \cdot k_y} + \frac{1}{k_x}}$$