Friday 9 Apr 2021 F. Morrison (1)

Example 6: Height of a packed bed absorber

How can we use mass transfer to design a packed bed gas absorber to achieve a desired separation?

★ REVISIT MOD 4 LECT IV

k_x can also be related to D_{AB} (EXAMPLE 9)

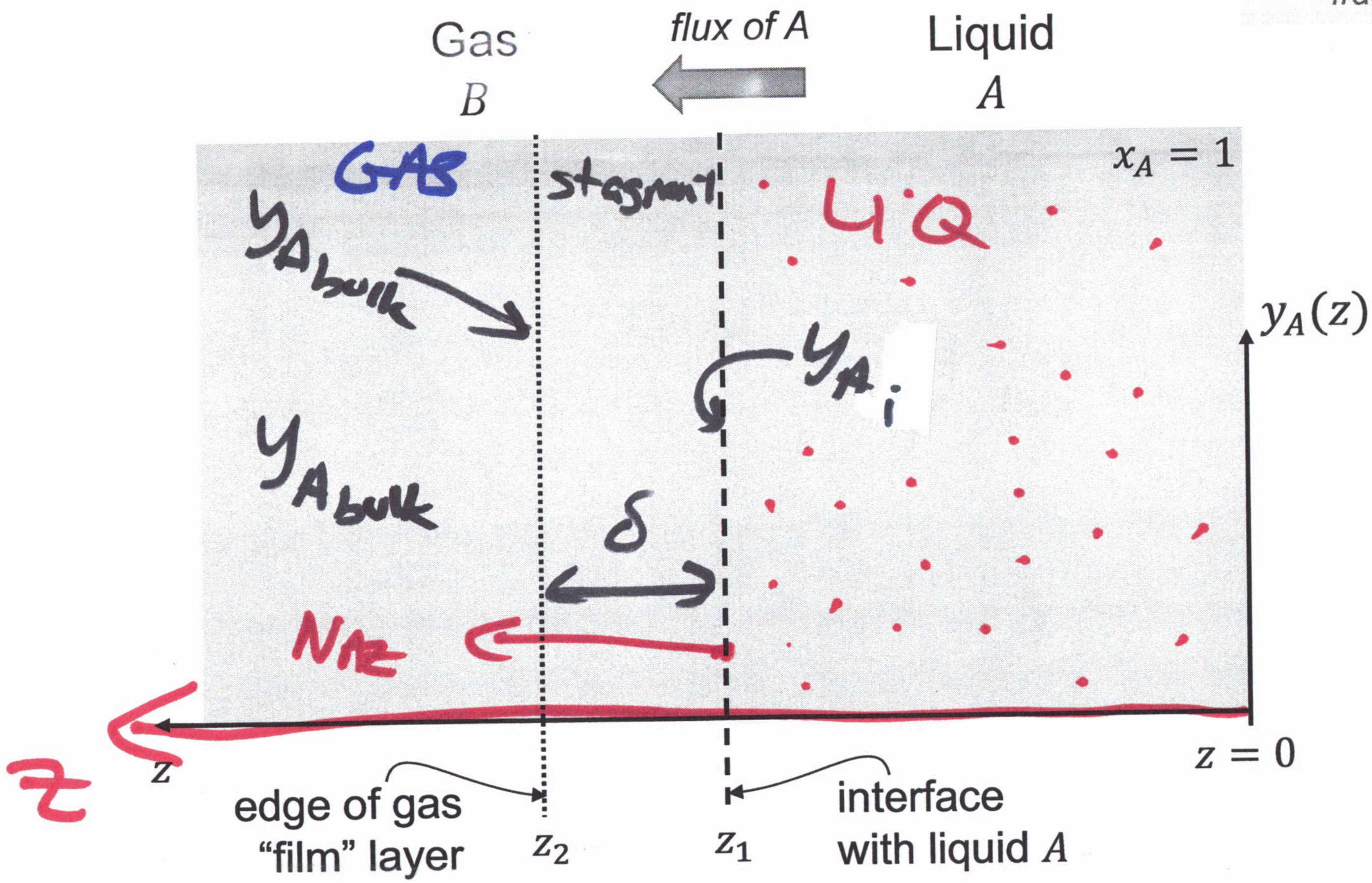
Example 6 is presented as a series of **linked examples** that navigate around apparent "dead ends" in modeling mass-transfer units

Identify a question	Invent something	Try to use it
1. How can we model a large, practical device dependent on mass transfer?	1. Apply the species A mass balance to a macroscopic C.V.	1. Lack a system to account for A going between phases
2. How an we account for A going between phases?	2. Invent k_x through linear driving force (LDF) model	2. Gets A *to* the boundary, but not *across*
3. How can we improve LDF model to cross the boundary (bulk-to-bulk transfer)?	3. Write LDF in both phases and combine to create overall effect of multiple resistances	3. Working, but can we devise a convenient shorthand?
4. Can we model a large, practical device, incorporating K_L, K_G to account for mass xfer between phases?	4. Yes	

CM3120

Example 9: The film model of 1D steady diffusion yields a composition distribution and an expression for the flux. What is the mass-transfer coefficient in the film model?

(we use x for liquid and y for gas mole fractions)



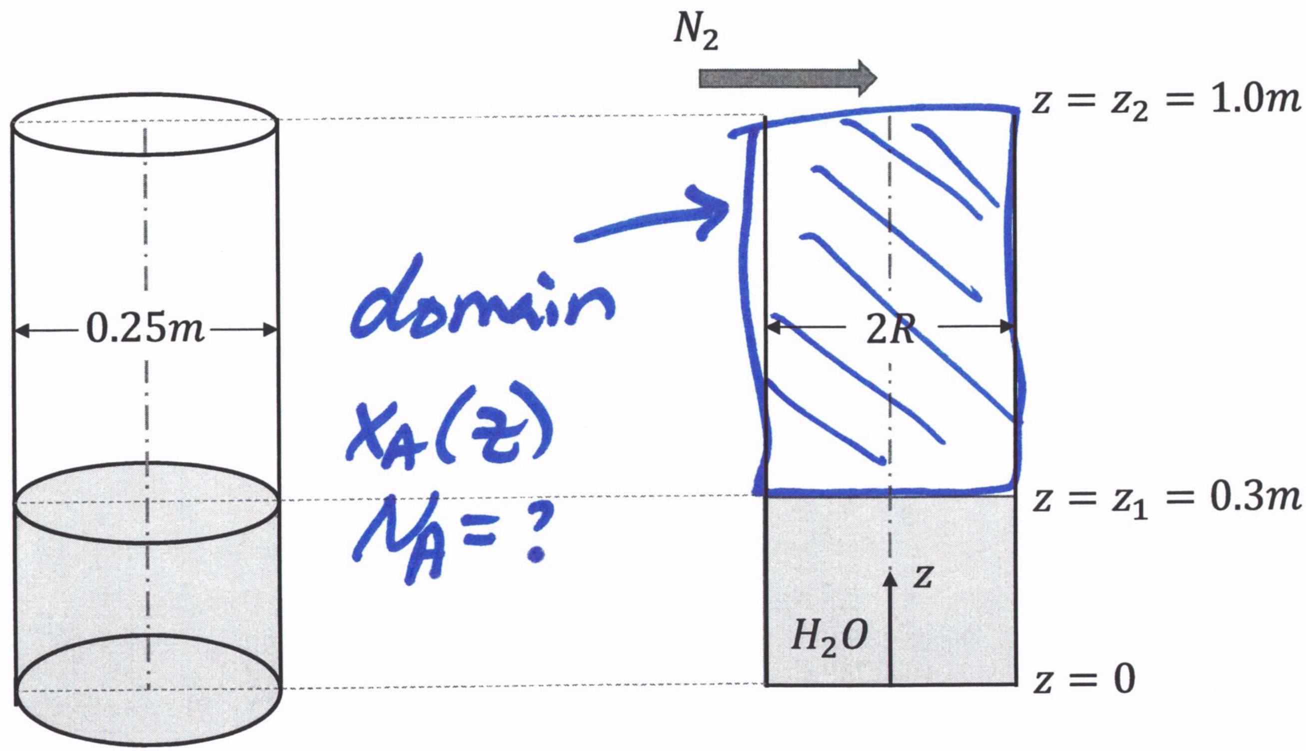
RECALL:

3

QUICK START

Example 1: Water $(40^oC, 1.0\ atm)$ slowly and steadily evaporates into nitrogen $(40^oC, 1.0\ atm)$ from the bottom of a cylindrical tank as shown in the figure below. A stream of dry nitrogen flows slowly past the open tank. The mole fraction of water in the gas at the top opening of the tank is 0.02. The geometry is as shown in the figure. **What is the rate of water evaporation?**

origin @ "film model"



BSL2, p547

Film model (see Ex 1, Lec II, Mod 3)

$$N_{Az} = \frac{c D_{AB}}{\delta} \ln\left(\frac{1-y_{Ab}}{1-y_{Ai}}\right)$$

We could use either approach, actually.

LINEAR DRIVING FORCE MODEL (GAS)

$$N_{Az} = k_y \left(y_{Ai} - y_{Ab}\right)$$

- Equate. **ANSWER**
- obtain: $k_y = \left(\frac{c D_{AB}}{\delta \, y_{B_{lm}}}\right)$

(remember $y_A + y_B = 1$)

//

5

There are numerous concentration units in use (practical consideration)

Linear-driving-force model (film coefficients): the flux of A from the bulk in the gas is proportional to the difference between the bulk composition and the composition at the interface.

The defining equations for the film mass-transfer coefficients:

mole frac y_A

Table 29.1 Individual mass-transfer coefficients

GAS

Driving force	Flux equation	Units of k
	Gas film	
Partial pressure (p_A)	$N_A = k_G(p_A - p_{A,i})$	kgmole/$m^2 \cdot s \cdot$ atm
Concentration (c_A)	$N_A = k_c(c_{AG} - c_{AG,i})$	kgmole/($m^2 \cdot s \cdot$ (kgmole/m^3)) or m/s
Mole fraction (y_A)	$N_A = k_y(y_A - y_{A,i})$	kgmole/$m^2 \cdot s$
	Liquid film	
Concentration (c_{AL})	$N_A = k_L(c_{AL,i} - c_{AL})$	kgmole/($m^2 \cdot s \cdot$ (kgmole/m^3)) or m/s
Mole fraction (x_A)	$N_A = k_x(x_{A,i} - x_A)$	kgmole/$m^2 \cdot s$

WRF, Ch29 p 596

And repeat for Example 10 ⑥

Example 10: The penetration model of 1D steady diffusion yields a composition distribution and an expression for the flux. What is the mass-transfer coefficient in the penetration model?

(we use x for liquid and y for gas mole fractions)