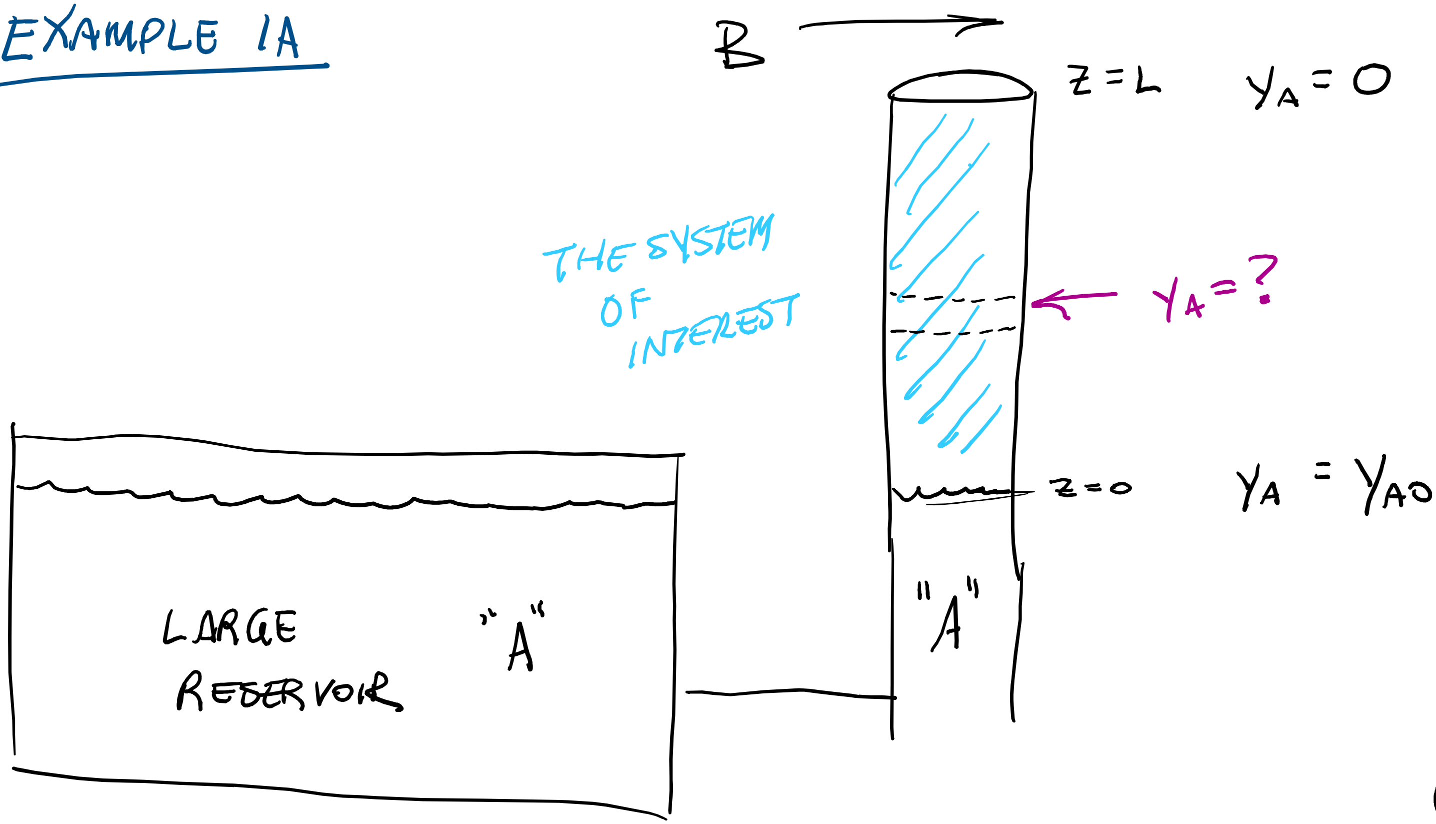
EXAMPLE 1A



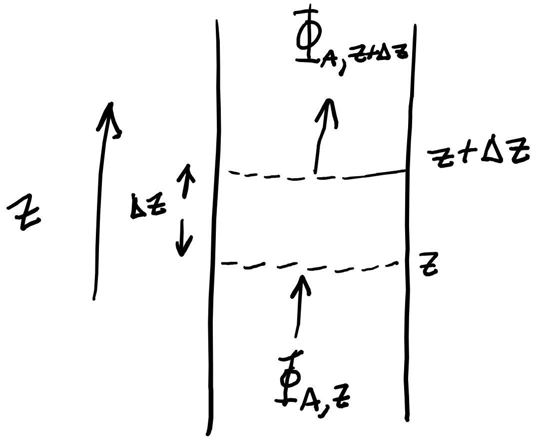
ASSUMPTIONS

1. CONSTANT P, T
2. A & B ARE IDEAL GAS (IN GAS PHASE)
3. GAS "B" IS INSOLUBLE IN "A".
4. LIQUID HEIGHT DOES NOT CHANGE DESPITE EVAPORATION (RESERVOIR)
5. "B" IS STAGNANT IN SYSTEM OF INTEREST.

STEP 1

DRAW & LABEL ON REPRESENTATIVE VOLUME ELEMENT

CROSS-SECTIONAL AREA = S



NOTE: FLUX IS ONLY IN z-DIRECTION

REMEMBER

MOLAR FLOW = MOLAR FLUX * AREA

STEP 2

PERFORM A MATERIAL BALANCE ON COMPONENT "A".

$$\cancel{ACC} = IN - OUT + \cancel{GEN}$$

$$0 = \left(\Phi_{A,z} S\right)\Big|_{z} - \left(\Phi_{A,z+\Delta z} S\right)\Big|_{z+\Delta z}$$

NOTE: $S \neq f(z)$ THUS S IS SAME AT z AS IT IS AT $z+\Delta z$

DIVIDE BY $-S\Delta z$

$$0 = \frac{\Phi_A\big|_{z+\Delta z} - \Phi_A\big|_z}{\Delta z}$$

EVALUATE AS $\Delta z \to 0$

$$\boxed{0 = \frac{d\Phi_A}{dz}}$$

FROM RESULT OF "FLUX EQUATION" (IN 2 SLIDES AHEAD)

THIS EQUATION IS THE RESULT OF A MATERIAL BALANCE.

(Z-DIRECTION ONLY)

WE COULD SOLVE THIS DIFF EQN IF WE HAD A BOUNDARY CONDITION IN TERMS OF FLUX.

~~@ $z=0$ $\Phi =$ __~~

STEP 3 USE "FLUX EQUATION" TO RELATE FLUX WITH CONCENTRATION.

GENERAL EQN $\vec{\Phi}_A = -cD_{AB}\vec{\nabla}y_A + y_A \sum \Phi_j$

FOR THIS SPECIFIC PROBLEM

- THERE ARE ONLY 2 COMPONENTS (A & B)
- FLUX IS ONLY IN Z-DIRECTION

$$\Phi_A = -cD_{AB}\frac{dy_A}{dz} + y_A(\Phi_A + \Phi_B)$$

- B IS STAGNANT $\Phi_B = 0$

SOLVE FOR Φ_A ....

$$\Phi_A = -\frac{cD_{AB}}{1-y_A}\frac{dy_A}{dz}$$

WE NOW HAVE AN EQUATION FOR Φ_A IN TERMS OF CONC (y_A)

$$\boxed{\frac{d}{dz}\left[-\frac{cD_{AB}}{1-y_A}\frac{dy_A}{dz}\right] = 0}$$

INTEGRATE...

$$-\frac{cD_{AB}}{1-y_A}\frac{dy_A}{dz} = C_1 = \Phi_A$$

$$-cD_{AB}\int\frac{dy_A}{1-y_A} = C_1\int dz$$

$$\underline{\underline{+cD_{AB}\ln(1-y_A) = C_1 z + C_2}}$$

cD_{AB} MUST NOT CHANGE WITH z, y_A.

(WHAT THIS REALLY MEANS IS T & P MUST BE CONSTANT).

STEP 4   APPLY BOUNDARY CONDITIONS   @ $z=0$ $y_A = y_{A0}$

@ $z=L$ $y_A = 0$

1) $y_A = y_{A0}$ @ $z=0$

$$cD_{AB}\ln[1-y_{A0}] = C_2$$

2) $y_A = 0$ @ $z=L$

$$\underbrace{cD_{AB}\ln[1-0]}_{0} = C_1 L + C_2$$

$$C_1 = -\frac{C_2}{L} = \frac{-cD_{AB}\ln[1-y_{A0}]}{L}$$

So,

$$c D_{AB} \ln(1 - y_A) = -\frac{c D_{AB} \ln(1 - y_{A0})}{L} z + c D_{AB} \ln(1 - y_{A0})$$

$$\ln(1 - y_A) = \left(-\frac{z}{L} + 1\right)\left(\ln(1 - y_{A0})\right)$$

$$\boxed{\ln(1 - y_A) = \ln(1 - y_{A0})\left(1 - \frac{z}{L}\right)}$$

$$1 - y_A = (1 - y_{A0})^{1 - z/L}$$

$$\boxed{y_A = 1 - (1 - y_{A0})^{1 - z/L}}$$

EITHER ONE OF THESE TWO EQNS COULD BE USED

"$1 - z/L$" IS AN EXPONENT

ANSWER QUESTIONS

1) Φ_A @ $z = L$

$$\Phi_A = C_1 = \frac{-cD_{AB}}{1-y_A}\frac{dy_A}{dz} = -\frac{cD_{AB}\ln(1-y_{A0})}{L}$$

SINCE GAS IS AN IDEAL GAS

$$c = \frac{P}{RT}$$

$$\boxed{\Phi_A = -\frac{P D_{AB} \ln(1-y_{A0})}{LRT}}$$

- FLUX IS CONSTANT
- $\ln(1-y_{A0})$ WILL ALWAYS BE NEGATIVE.

Φ_A IS ALWAYS POSITIVE, OCCURS IN $+z$ DIRECTION

2) AT $z = \frac{L}{2}$ WHAT IS y_A?

$$y_A = 1 - (1 - y_{A0})^{(1 - z/L)}$$

$$y_A = 1 - (1 - y_{A0})^{0.5}$$

IT **DEPENDS** ON VALUE OF y_{A0}

IF		@ $z = L/2$
	$y_{A0} = 0.10$	$y_A = 0.051$
	$y_{A0} = 0.20$	$y_A = 0.106$
	$y_{A0} = 0.30$	$y_A = 0.163$

3) $\dot{n}_A$ @ $z = L$

$$\dot{n}_A = \Phi_A \cdot S$$

BOTH Φ_A & S ARE NOT FUNCTIONS OF z.

$$\boxed{\dot{n}_A = -\frac{P D_{AB} S \ln(1 - y_{A0})}{LRT}}$$