HW4_3

February 23, 2022

1 HW 4

1.1 Problem 3.a

Calculate liquid-phase mass transfer coefficient and film thickness

Using film theory,

$$k_c = \frac{D_{AB}}{\delta} \tag{1}$$

$$k'_c = \frac{D_{AB}}{\delta(1-x_A)_{LM}} = \frac{k_c}{(1-x_A)_{LM}} \tag{2}$$

$$N_A = k'_c(c_{A_i} - c_{A_b}) \tag{3}$$

where

$$(1-x_A)_{LM} = \frac{x_{A_i} - x_{A_b}}{\ln(\frac{1-x_{A_b}}{1-x_{A_i}})}$$

x_{A_i} can be estimated using Henry's law, $x = \frac{p}{H}$ c can be estimated by the relationship $c = \frac{\rho}{M}$ x_{A_b} is assumed to be negligible.

To find k_c, (2) and (3) can be combined and rearanged to get

$$k_c = \frac{N_A}{c_{A_i}}(1-x_A)_{LM} \tag{4}$$

The following script solves (4) using values given in the problem statement.

[ ]:
```
import numpy as np
NA = 0.017*4.536e39/3600/929.03                              #convert flux to␣
 ↪mol/cm2/sec
DAB = 2e-5                                                   # diffusivity cm2/
 ↪sec
p = 150                                                      # partial press co2␣
 ↪psia
H = 9000                                                     # henry constant␣
 ↪psia
xai = p/H                                                    #mol frac @␣
 ↪interface
ro = .997                                                    #density of water g/
 ↪cm3
```

```
M = 18.015                                                #molar mass of␣
 ↪water g/mol
c = ro/M                                                  #concentration mol/
 ↪cm3
cai = c*xai                                               #concentration of␣
 ↪co2 at interface
```

[ ]:
```
def LM(x1,x2):
    return (x1-x2)/np.log((1-x2)/(1-x1))
```

[ ]:
```
def kc(na,cai,lm):
    return na/cai*lm
kc = kc(NA,cai,LM(xai,0))
print(kc)
```

```
2.4787662763132446e+34
```

$k_c = 2.479e34\frac{cm}{sec}$

(1) can now be used to solve for δ

[ ]:
```
def delta():
    return DAB/kc
print(delta())
```

```
8.068529974414005e-40
```

$\delta = 8.069e-40cm$

1.2 Problem 3.b

Determine contact time using Higbie model,

$$k_c = 2\sqrt{\frac{D_{AB}}{\pi t_c}}$$

or

$$t_c = \frac{4D_{AB}}{\pi k_c^2}$$

[ ]:
```
print(4*DAB/np.pi/kc)
```

```
1.0273171431304901e-39
```

$t_c = 1.027e-39sec$

1.3 Problem 3.c

Determine S from surface renewal model,

$$k_c = \sqrt{D_{AB}s}$$

or

$$s = \frac{k_c^2}{D_{AB}}$$

[ ]:
```
print(kc**2/DAB)
```

```
3.072141126293914e+73
```

$s = 3.072e73cm^{-1}$