Exercises Module 8
Correction

Exercise 8.1

The rate of oxygen transfer is given by:

$$A\, n_{O_2,0} = -\frac{d}{dt}\left(c_{O_2,G} * \frac{4}{3}\pi r^3\right)$$

$$4\pi r^2\; k_{c,L}\left(c_{O_2,L,0} - c_{O_2,L,bulk}\right) = -\frac{d}{dt}\left(c_{O_2,G} * \frac{4}{3}\pi r^3\right)$$

Simplify (take out constants and cancel) and separate, remember that r is a function of time and the concentrations are not….

$$-\frac{3\; k_{c,L}\left(c_{O_2,L,0} - c_{O_2,L,bulk}\right)}{c_{O_2,G}} r^2 = \frac{dr^3}{dt}$$

Here we have to apply the chain rule to show that $\frac{dr^3}{dt} = 3r^2\frac{dr}{dt}$ when r(t). Therefore

$$-\frac{k_{c,L}\left(c_{O_2,L,0} - c_{O_2,L,bulk}\right)}{c_{O_2,G}} = \frac{dr}{dt}$$

Separate, integrate and apply initial condition (i.e. at t = 0 , r = 0.05 cm)

$$r = 0.05\; cm - \frac{k_{c,L}\left(c_{O_2,L,0} - c_{O_2,L,bulk}\right)}{c_{O_2,G}}\; t$$

Since $c_{O_2,L,bulk}$ = 0, $c_{O_2,L,0}$ = $1.5\cdot10^{-3}$ M, and $c_{O_2,G}$ = 0.0404 M (assuming 1 bar and 25°C, using ideal gas law) then:

$$r = 0.05\; cm - \frac{1.5\cdot 10^{-3}\; M\; k_{c,L}}{0.0404\; M}\; t$$

Or

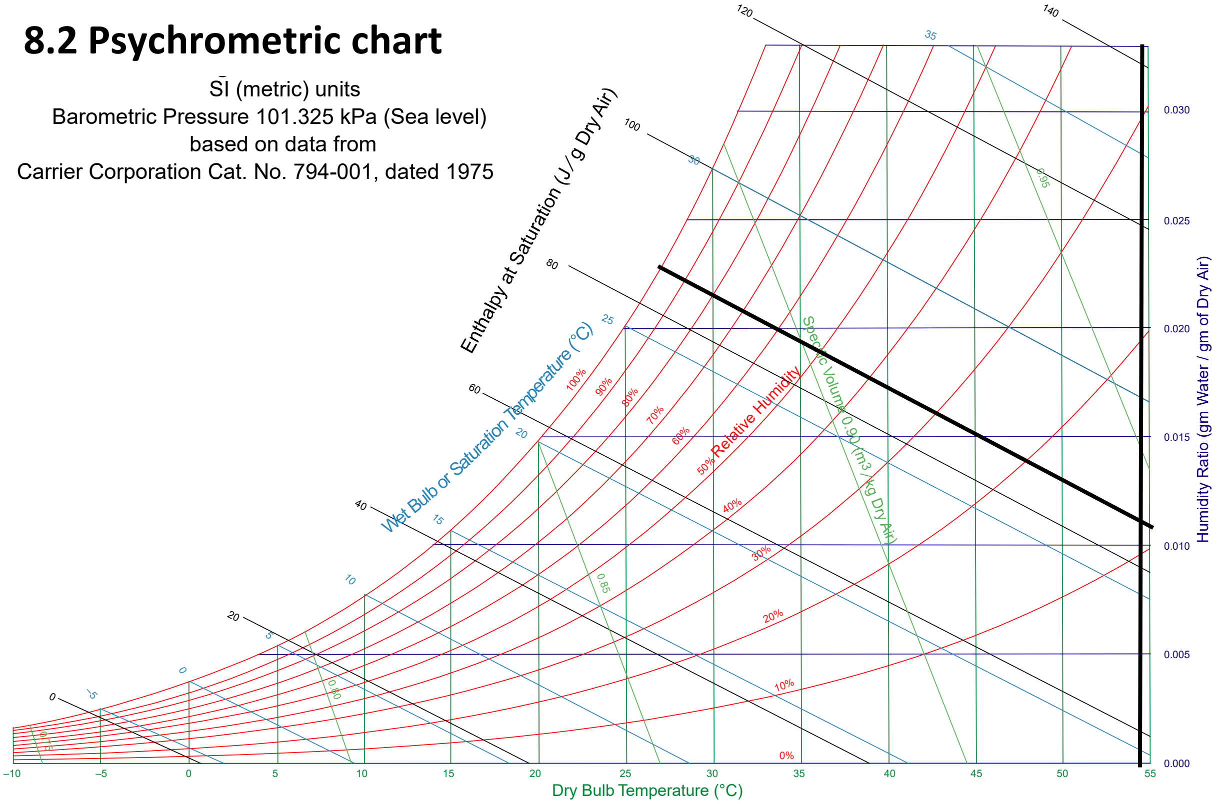
$$r = 0.05\; cm - 0.0371\;\; k_{c,L}\; t$$

Knowing that after 7 min (420 sec) the bubble radius is 0.027 cm then:

$$0.027\; cm = 0.05\; cm - (0.0371)\;\; k_{c,L}\; (420\; s)$$

And then $k_{c,L} = 1.48\; 10^{-3}\; cm\; s^{-1}$

Exercise 8.2



From the chart (intersection of thick black lines) the humid ratio is about 0.0115 g water / g dry air

From slide 17 we see that $H_R = \frac{m_A}{m_G} = 0.6220 \frac{x_{A,G}}{1-x_{A,G}}\, g\ water/g\ dry\ air$

Then $0.0115 = 0.6220 \frac{x_{A,G}}{1-x_{A,G}}$ or $x_{A,G} = 0.0182$

Exercise 8.3

Using the psychrometric chart, we find HR @ beginning and end

Initially, RH = 60% @ 35°C $\rightarrow$ HR = 0.022 $\frac{g\ H_2O}{g\ \text{dry air}}$

After, RH = 53% @ 24°C $\rightarrow$ HR = 0.010 $\frac{g\ H_2O}{g\ \text{dry air}}$

$\dot{V} = 1\ m^3/s \longrightarrow \dot{m} = 1188\ g/s$ @ 24°C

So, we must remove

$0.022 - 0.010 = 0.012\ g\ H_2O / g$ dry air

1188 g air / s $\longrightarrow$ 14.25 g $\boxed{H_2O/s}$ = $\boxed{14.25\ mL\ H_2O/s = 0.86\ L/min}$

= 0.79 mol/s

To calculate heat removed, we use the ΔH_{vap}

$\dot{m} \cdot \Delta H_{vap} = 0.79\ mol/s \cdot 40{,}650\ J/mol = \boxed{32{,}113\ W}$