Calibrating ~~C_F~~ and C_p.

C_p : grab data from task 1 or others.

calculate : $\frac{z_a - x_a}{y_a - z_a} = \frac{R}{P} = \frac{C_p}{C_r}$. set $C_r = 50$ sccm / mm

O_2 mol: $\frac{0.215 - \frac{8.5}{100}}{\frac{33}{100} - 0.215} = 0.9398\, m_1 = \frac{C_p}{C_r}$ [for data 1 of task 1]

=) ~~0.934 C_r = C_p~~ $\frac{C_p}{C_r} = \frac{(\text{permeate reading})}{(\text{retentate reading})} = \frac{88 \text{ mm}}{89.5 \text{ mm}} = 0.983$

plot $\frac{z_a - x_a}{y_a - z_a} = 0.934$ against $\frac{C_p}{C_r} = 0.983$ with other points.

find m_1. with excel linest : $m_1 = 0.886$ with 0 intercept.

$\boxed{\text{get } C_p = 0.886 \cdot 50 = 44.3 \text{ sccm / mm}}$

Error:

assume both reading has ± 2% error ~~accuracy~~ from manufacture.

assume % O_2 reading has ± 0.2% (0.002) error.

high error

$\frac{C_p + 0.1 C_p}{C_r - 0.1 C_r} = \frac{C_p (1+0.1)}{C_r (1-0.1)} = \frac{C_p}{C_r}\left(\frac{1.02}{0.98}\right)$.

= ~~1.2014~~ 1.023

low error

$\frac{C_p}{C_r}\left(\frac{0.98}{1.02}\right) = $ ~~0.8042~~ 0.944.

high error

$\frac{z_a - (x_a - 0.002)}{(y_a - 0.002) - z_a} = 1.168$

low:

$\frac{z_a - (x_a + 0.002)}{(y_a + 0.002) - z_a} = 1.094$.

then,

m_1 high : $\cancel{1.13}$ 0.968 $\Rightarrow C_p = \cancel{56.883}$ 48.4 sccm/min.

low : $\cancel{0.7039}$ 0.829 $\Rightarrow C_p = \cancel{35.3}$ 41.5 sccm/min

$$C_p = 44.3 \pm \frac{(\cancel{56.9}\ 48.4 - 44.3)}{(\cancel{44.3}\ 44.3 - \cancel{35.3}\ 41.5)} = 44.3 \begin{matrix} + \cancel{12.6}\ 4.1 \\ - \cancel{9}\ 2.8 \end{matrix} \text{ sccm}$$

avg error $\cancel{\frac{12.6+9}{2} = 10.8}$ $\frac{4.1+2.8}{2} = \cancel{5.45}$ 3.55

Calibrate C_F.

$$\boxed{C_p = 44.3 \pm \cancel{10.8}\ \cancel{5.45}\ 3.55 \text{ sccm}}$$

Sccm of retentate : $50 \cdot 89.5 = 4475$ sccm ± 89.5 $= R$

pernate : $88 \cdot 44.3 = 3898$ sccm $\pm$ $\cancel{950.4}$ 312.4 sccm $= P$

$R + P = 4475 + 3898 = 8373.8 \pm$ $\cancel{1040.4}$ 401.9 sccm [4.8%]

Feed P (psi) $= 69 + 14.7 = 83.7$ psi

and ± 1 psi on P_F: error $\cancel{20}$% on reading:

$$\left(\frac{P_F}{P_{atm}}\right)^{\frac{1}{2}} r_F = \left(\frac{83.7}{14.7}\right)^{\frac{1}{2}} 14.5 = 34.6 \pm \cancel{3.46}\ 0.692$$

$\hookrightarrow \cancel{\left(\frac{3.48 + 3.44}{2}\right)} = 3.46$

plot $(R+P)$ vs $\left(\frac{P_F}{P_{atm}}\right)^{\frac{1}{2}} r_F$ with 0 intercept:

$C_F = 233.97 = 234$ sccm/min.

high $C_F = \cancel{307.8}$ $\cancel{254}$ 254 sccm/min

low $C_F = \cancel{176.3}$ 213 sccm/min

avg error : $\dfrac{(\cancel{307.8}\ 254.4 - 234) + (234 - \cancel{176.3}\ 213)}{2} \approx \cancel{65.75}$ $\cancel{47.23}$ 20.5

$$\boxed{C_F = 234 \pm \cancel{65.75}\ \cancel{47.25}\ 20.5 \text{ sccm/min}}$$

$(\cancel{20}\%)$ $\cancel{8.55}$ (8.77)

Calculating mol flux from sccm → mmol/s.

Feed flow actual: (data 2 on task 1)

$$\dot{V}_F = C_F \cdot r_F \cdot \left(\frac{P_F}{P_{atm}}\right)^{\frac{1}{2}} = \cancel{12}\ \cancel{12} \cdot 14.5 \cdot 234 \cdot \left(\frac{83.7}{14.7}\right)^{\frac{1}{2}}$$

$\pm\ \cancel{800}\ 762.5$ $\boxed{9.4\%}$

$= 8095.5$ sccm ~~[illegible]~~

total:

$$J_{Feed} = \frac{\dot{V}\ (cm^3/s)}{22.4\ \left[\frac{mol}{dm^3}\right]} \cdot \frac{1\ dm^3}{1000\ cm^3} \cdot \frac{1000\ mmol}{mol} \cdot \left(\frac{1\ min}{60\ s}\right) = \left[\frac{mmol}{s}\right]$$

standard ~~air den~~ air molar density at room temp

$$\boxed{= \frac{8095.5}{22.4} \cdot \frac{1}{1000} \cdot 1000 \cdot \frac{1}{60} = 6.02\ mmol/s} \pm \cancel{0.700}\ 0.566$$

~~$J_{per} = 6.02$~~

$\dot{V}_p = C_p r_p = 88 \cdot 44.30 = 3899$ sccm ~~mmol/s~~

$$\boxed{J_{per} = \frac{3899}{22.4} \cdot \frac{1}{60} = 2.9\ mmol/s} \pm \cancel{0.29}\ 0.058\ (2\%)$$

$89.5\ (2\%)$

$\dot{V}_r = C_r r_r = \cancel{66}\ 89.5 \cdot 50 = \cancel{3300}\ 4475$ sccm ~~mmol/s~~ $\pm\ \cancel{3.30}\ \cancel{66}$

$\pm\ 0.066$

$$\boxed{J_{ret} = 3.33\ mmol/s}$$

$$\boxed{\%\ err: \frac{\cancel{0.02}\ \cancel{0.78}\ 0.566}{6.02} \cdot 100 \approx \cancel{3.49}\ 9.4\%}$$

Mass balance: $6.02 - (2.9 + \cancel{3.29}\ 3.33) \approx \cancel{0.02}\ \cancel{0.78}\ 0.21$ mmol/s

close to 0. and within error bound. $\left[\frac{0.21}{6.02} \cdot 100\right] = 3.48\%$

Mass conserved for total and most other data.

~~Calc J flux.~~

O_2 flux:

$J_{O_2,F} = 0.215 \cdot 6.02 = 1.295$ mmol/s

$J_{O_2,P} = 2.9 \cancel{\text{mot}} \cdot (O_2\%\text{ reading at perm}) = 2.9 \cdot (0.348) = 1.009$ mmol/s

$J_{O_2,V} = \cancel{2.9} \; 3.33 \; (\text{———— ret}) = 3.33 \cdot (0.09) = 0.2996$

≈ 0.30 mmol/s

N_2 flux:

$J_{N_2,F} = 0.715 \cdot 6.02 = 4.73$ mmol/s

$J_{N_2,P} = 2.9(1 - 0.348) = 1.89$ mmol/s

$J_{N_2,V} = 3.33(1 - 0.09) = 3.03$ mmol/s.

$\frac{0.014}{1.295} \cdot 100 = 1.08\%$

M.B of O_2: $1.295 - (1.009 + 0.3) = -0.014$. conserved account for err.

———— N_2: $4.73 - (1.89 + 3.03) = -0.19$ consered account for err.

$\frac{0.19}{4.73} \cdot 100 = 4.017\%$

All M.B are less than 5% error, well conserved, considering rotameter reading has 5% - 10% error.

$\boxed{\text{recover of } O_2 \text{ (Perm) and } N_2 \text{ (retentate):}}$

$\cancel{z}$ $O_2\%$: $\dfrac{J_{per,O_2}}{J_{Feed,O_2}} = \dfrac{\cancel{2.9}\ 1.0095}{\cancel{6.02}\ 1.295} \cdot 100 = \cancel{48.17}\ 78\ \%$

$N_2\%$: $\dfrac{J_{ret,N_2}}{J_{Feed,N_2}} = \dfrac{\cancel{3.03}\ 2.246}{3.9} \quad \dfrac{3.0299}{4.728} \cdot 100 = 64\%$

done for other data and plot on graph.

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mean O_2 ΔP (psi): (for ~~1 data point~~ ex data point.):

$$\text{Avg } \Delta P = \frac{(P_{feed} \cdot z_{O_2} - P_{per} \cdot y_{O_2})}{2} + \frac{(P_{ret} x_{O_2} - P_{per} y_{O_2})}{2}$$

$$= \frac{((22+14.7)\ \cancel{36.7} \cdot 0.215 - 14.7 \cdot 0.353)}{2} + \frac{(34.7 \cdot 0.209 - 14.7 \cdot 0.353)}{2}$$

$= \cancel{18.618}\ 2.37$ psi

mean N_2 ΔP (psi): (same data):

$$\text{Avg } \Delta P = \left[\frac{(36.7 \cdot 0.785 - 14.7 \cdot (1-0.353))}{2}\right] + \left[\frac{(34.7 \cdot (1-0.209) - 14.7(1-0.353))}{2}\right]$$

$= 18.63$ psi