11.1 a) Check to see if the results are consistent

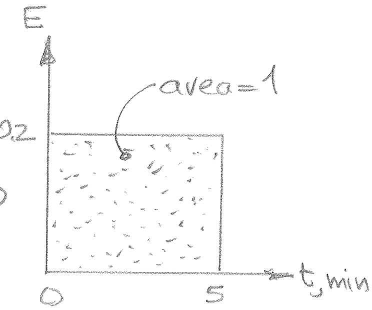
By material balance : area $= \frac{M}{v} = \frac{1\,mol}{4\,lit/min} = 0.25$ mol·min/lit
From the graph : area $= (0.05\,mol/lit)(5\,min) = 0.25$ mol·min/lit
check

So the results are consistent ← a)

b) Mean $\bar{t} = V/v$ or $V = \bar{t}v = 2.5 \times 4 = 10$ lit ← b)
by inspection

c) Find the E curve. From t=0 to 5

$$E = \frac{C}{M/v} = \frac{C}{1/4} = 4C = 0.2$$ ← c)



11.3 a) Check for consistency

By material balance : $\bar{t} = V/v = 60/4 = 15$ sec
But from the experimental curve :
compare

$$\bar{t} = \frac{1}{3}(18\times1 + 21\times2) = 20 \text{ sec}$$

The tracer comes out too late. Thus the experiment was done incorrectly. Inconsistent ← something is wrong

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11.5 a) From experiment

Mean of the curve: $\bar{t} = \frac{\Sigma tC}{\Sigma C} = \frac{30(15\cdot\frac{h}{2}) + 65(90\cdot\frac{h}{2})}{105\cdot\frac{h}{2}} = 60$ days

Area under the curve : $A = \frac{(120-20)}{2}\cdot10^{-6} = 52.5$ $\frac{\text{unit}\cdot\text{days}}{m^3}$

From the material balance

$$\text{Area} = \frac{M}{v}$$

$\therefore\ M = (A)v = \left(52.5\times10^{-6}\,\frac{\text{unit day}}{m^3}\right)\left(6000\,\frac{m^3}{s}\right)\left(\frac{3600\times24\,s}{day}\right) = 27216$ units ← a)

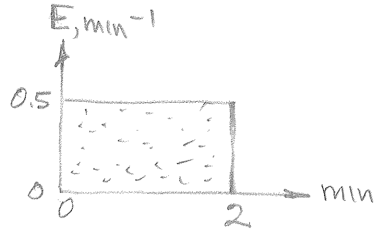
b) Also because $\bar{t} = \frac{V}{v}$

$$V = (\bar{t})v = 60\text{ days}\left(6000\,\frac{m^3}{s}\right)\left(\frac{3600\times24\,s}{day}\right) =$$
$$= 3.11\times10^{10}\,m^3$$ — b)

11.7 Calculate the conversion for

$A \rightarrow R$, $C_{A0} = 1\ \text{mol/lit}$

$-r_A = (2\ \text{mol}^{1/2}/\text{lit}^{1/2}\cdot\text{min})\, C_A^{\frac{1}{2}}$



The performance equation is

$$\frac{C}{C_0} = \int_0^\infty \left(\frac{C}{C_0}\right)_{batch} E\, dt$$

from Eq 3.29

$$(n-1)kC_{A0}^{n}\,t = \left(\frac{C_A}{C_{A0}}\right)^{1-n} - 1$$

or $(-\frac{1}{2})(2)(1)t = \left(\frac{C_A}{C_{A0}}\right)^{1/2} - 1$ — for a batch of material

or $\frac{C_A}{C_{A0}} = (1-t)^2$

$$\therefore \frac{C}{C_0} = \int_0^2 (1-t)^2 \left(\tfrac{1}{2}\right) dt = \frac{0.5}{3}(1-t)^3\Big|_2^0 = \frac{1}{6}(1+1) = \frac{1}{3}$$

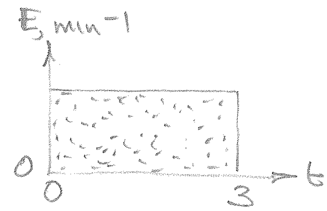
$$\therefore X_A = \frac{2}{3}$$

11.9 Calculate the conversion for

$A \longrightarrow R$ $C_{A0} = 6$

$-r_A = 3\ \text{mol/lit}\cdot\text{min}$

zero order reaction



The performance equation is $\frac{C_A}{C_{A0}} = \int \left(\frac{C_A}{C_{A0}}\right) E\, dt$

From Eq 3.31 ... $\frac{C_A}{C_{A0}} = 1 - \frac{kt}{C_{A0}}$ for $t < \frac{C_{A0}}{k} = \frac{6}{3} = 2$

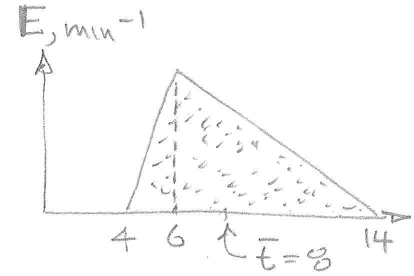
$\frac{C_A}{C_{A0}} = 0$ for $t > 2$ — replace into above

$$\frac{C_A}{C_{A0}} = \int_0^2 \left(1 - \frac{kt}{C_{A0}}\right)\frac{1}{3}dt = \int_0^2 \left(1 - \frac{3}{6}t\right)\frac{1}{3}dt = \frac{1}{6}\int_0^2 (2-t)dt$$

$$= \frac{1}{6}\,\frac{(2-t)^2}{2}\Big|_2^0 = \frac{1}{6}\left[\frac{2^2}{2} - 0\right] = \frac{1}{3}$$

$$\therefore X_A = \frac{2}{3}$$

11.11 Calculate the conversion for



$$A \rightarrow R \qquad \begin{array}{l} C_{A0} = 0.1 \text{ mol/lit} \\ -r_A = 0.03 \text{ mol/lit}\cdot\text{min} \end{array}$$

zero order

Performance equation

$$\frac{C_A}{C_{A0}} = \int \frac{C_A}{C_{A0}} E\, dt$$

zero order

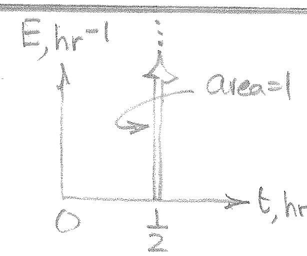
From Eq 3.31 ... $\dfrac{C_A}{C_{A0}} = 1 - \dfrac{kt}{C_{A0}} = 1 - \dfrac{0.03}{0.1} t$ ... for $t < \dfrac{C_{A0}}{k} = \dfrac{0.1}{0.03} = 3.33$ min

$\dfrac{C_A}{C_{A0}} = 0$ ... for $t < 3.33$ min

Here nothing leaves the reactor before 4 min, so everything has reacted

$$C_{Af} = 0, \; X_{Af} = 1$$

11.13 For the solid particles



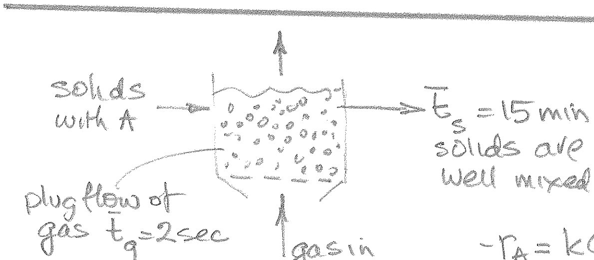
$$\overline{1-X} = \int (1-X) E\, dt = \int_0^1 \left(1 - \frac{t}{\tau}\right)^3 \delta(t - t_0)\, dt$$

$\tau = 1$ hr

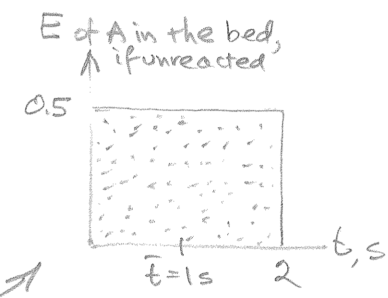
$$= (1-t)^3 \Big|_{\text{at } t = \frac{1}{2}} = \left(\tfrac{1}{2}\right)^3 = 0.125$$

$$\therefore \bar{X} = 1 - 0.125 = 0.875$$

11.15



$$-r_A = kC_A = (1\text{ sec}^{-1})C_A$$



Conversion of A

A is released uniformly by solids, so

$$\frac{C_A}{C_{A0}} = \int \left(\frac{C_A}{C_{A0}}\right) E\, dt = \int_0^2 e^{-kt}\, 0.5\, dt = 0.5 \int_0^2 e^{-t}\, dt = 0.5\, e^{-t} \Big|_2^0 = 0.4323$$

$$\therefore X_A = 0.5677$$

fraction of A decomposed.