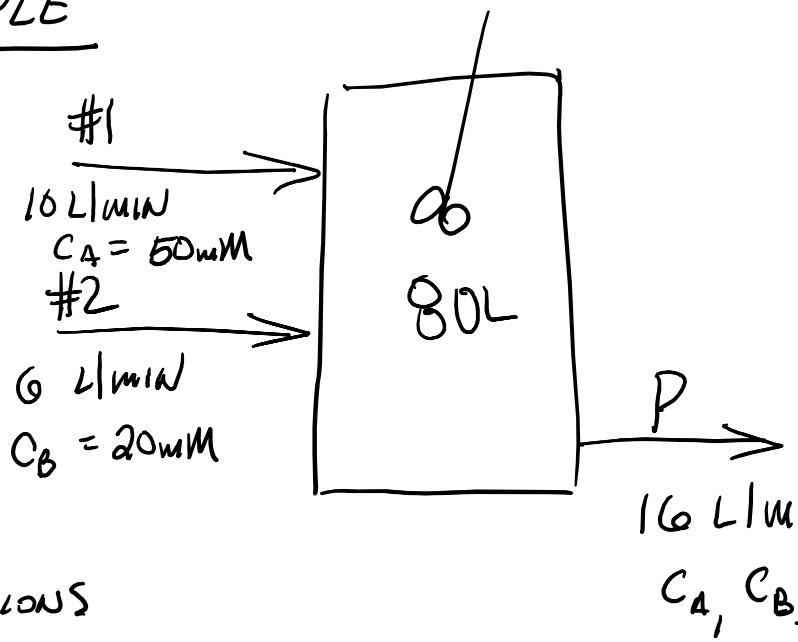
A FINAL EXAMPLE

$$2A + B \rightarrow 3C$$

$$R_B = -k c_B$$

$$k = 0.4 \text{ min}^{-1}$$



INITIAL CONDITIONS

$C_{A0} = 50$ mM

$C_{B0} = 0$ mM

$C_{C0} = 0$ mM

"B" BALANCE

ACC = IN − OUT + GEN

$$\frac{d(c_B V)}{dt} = Q^{\#2} c_B^{\#2} - Q^P c_B^P - V k c_B$$

REFER TO CONC OF B IN THE REACTOR

REFERS TO CONC OF B EXITING REACTOR.

$$V \frac{dc_B}{dt} = Q^{\#2} c_B^{\#2} - Q^P c_B - V k c_B$$

L – V

t – min

conc. mmol/L

$$80 \frac{dc_B}{dt} = (6)(20) - 16 c_B - (80)(0.4) c_B$$

$$\boxed{\frac{dc_B}{dt} = 1.5 - 0.6 c_B}$$

@ $t = 0$

$c_B = 0$

$c_B = f(t)$

AT STEADY STATE (SS) $\frac{dc_B}{dt} = 0 = 1.5 - 0.6 c_{B(SS)}$

$$c_{B(SS)} = \frac{1.5}{0.6} = \underline{2.5 \text{ mmol}/L}$$

"A" BALANCE

$$ACC = IN - OUT + GEN$$

$$\frac{d(c_A V)}{dt} = Q^{\#1} c_A^{\#1} - Q^P c_A^P - V R_A$$

$R_A = 2 R_B$

"'A' IS CONSUMED AT TWICE THE RATE THAT 'B' IS CONSUMED"
JOSH OZBURN
NOV 8, 2021

$$\frac{d(c_A V)}{dt} = Q^{\#1} c_A^{\#1} - Q^P c_A^P - V(2 k c_B)$$

$$80 \frac{dc_A}{dt} = (10)(50) - 16 c_A - (80)(2)(0.4) c_B$$

$t = 0 \quad c_{A0} = 50$

$$\boxed{\frac{dc_A}{dt} = 6.25 - 0.2 c_A - 0.8 c_B}$$

"C" BALANCE

ACC = IN − OUT + GEN

$$\frac{d(c_c V)}{dt} = 0 - Q^P c_c^P + V\left(R_c \right)$$

$$V\frac{dc_c}{dt} = -Q^P c_c^P + V\left(3 k c_B\right)$$

"C" IS GENERATED

NOTE!

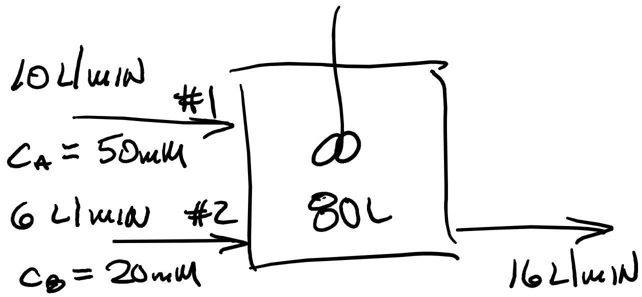
RATE OF C FORMATION IS 3X RATE OF B CONSUMPTION

$$80\frac{dc_c}{dt} = -16c_c + 80(3)(0.4)c_B$$

$$\boxed{\frac{dc_c}{dt} = -0.2c_c + 1.2c_B}$$

@ $t=0$
$c_{c_0} = 0$

SUMMARY



$$\frac{dC_B}{dt} = 1.5 - 0.6\,C_B$$

$$\frac{dC_A}{dt} = 6.25 - 0.2\,C_A - 0.8\,C_B$$

$$\frac{dC_C}{dt} = -0.2\,C_C + 1.2\,C_B$$

INITIAL CONDITIONS

$C_{A0} = 50$ mM

$C_{B0} = 0$ mM

$C_{C0} = 0$ mM

$$2A + B \rightarrow 3C$$

AT STEADY-STATE $(t \rightarrow \infty)$

$0 = 1.5 - 0.6\,C_{B(ss)}$ $\quad C_{B(ss)} = 2.5$ mM

$0 = 6.25 - 0.2\,C_{A(ss)} - 0.8\,(2.5)$

$C_{A(ss)} = 21.25$ mM

$0 = -0.2\,C_C + 1.2\,(2.5)$

$C_{C(ss)} = 15.0$ mM

THE SYSTEM IS OPERATING AT STEADY-STATE, WHAT HAPPENS IF SUDDENLY....

1) THE STREAM #2 CONC $C_B = 40\,mM$

NEW "B" BALANCE WOULD BE

$$80\frac{dc_B}{dt} = (6)(40) - 16c_B - (80)(0.4)c_B$$

$$\frac{dc_B}{dt} = 3 - \frac{16c_B}{80} - 0.4c_B$$

$$\boxed{\frac{dc_B}{dt} = 3 - 0.6c_B}$$

$t=0$

$C_{B0} = 2.5\,mM$

(STEADY-STATE CONC)

$0 = 3 - 0.6c_{B(ss)}$

$3 = 0.6c_{B(ss)}$

$5 = c_{B(ss)}$

NOTE: NEW STEADY-STATE CONC. OF "B" WILL BE $C_{B(ss)} = 5.0\,mM$

DOES THIS CHANGE AFFECT "A" OR "C" BALANCE?

$$\frac{dc_A}{dt} = 6.25 - 0.2c_A - 0.8c_B \qquad \text{(UNCHANGED)}$$

@ $t=0$

$$\left.\begin{aligned} c_A &= 21.25\ mM \\ c_B &= 2.5\ mM \end{aligned}\right\} SS$$

NEW STEADY-STATE

$$\begin{aligned} 0 &= 6.25 - 0.2c_{A(ss)} - 0.8c_{B(ss)} \\ &= 6.25 - 0.2c_{A(ss)} - 0.8(5) \end{aligned}$$

$$c_{A(ss)} = 11.25\ mM$$

$$\frac{dC_C}{dt} = -0.2C_C + 1.2C_B$$

(UNCHANGED)

$t=0$

$$\left.\begin{aligned} C_C &= 15\text{ mM} \\ C_B &= 2.5\text{ mM} \end{aligned}\right\} SS$$

NEW STEADY-STATE:

$$0 = -0.2\,C_{C(SS)} + 1.2(5)$$

$$\underline{C_{C(SS)} = 30\text{ mM}}$$

2) STREAM #2 IS TERMINATED

FLOWRATE OUT IS NOW 10 L/min!

"B" BALANCE:

$$V \frac{dc_B}{dt} = -10 c_B - (80)(0.4) c_B$$

$$80 \frac{dc_B}{dt} = -10 c_B - (80)(0.4) c_B$$

$$\frac{dc_B}{dt} = -0.125 c_B - 0.4 c_B$$

$$\boxed{\frac{dc_B}{dt} = -0.525 c_B}$$

@ $t = 0$

$c_{B0} = 2.5\,mM$

(ORIGINAL STEADY-STATE)

NEW STEADY-STATE $c_B = 0$

"A" BALANCE

FLOWRATE CHANGES TO 10 L/MIN!

$$V\frac{dc_A}{dt} = (10)(50) - 10c_A - (80)(2)(0.4)c_B$$

$$\boxed{\frac{dc_A}{dt} = 6.25 - 0.125c_A - 0.8c_B}$$

@ $t=0$

$C_{A0} = 21.25\,mM$

$C_{B0} = 2.5\,mM$

NEW STEADY-STATE

$$0 = 6.25 - 0.125c_A - 0.8(0)$$

$$C_{A(ss)} = 50\,mM$$