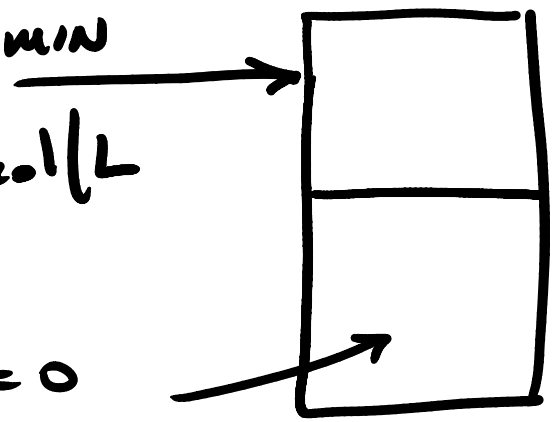
$Q^{IN} = 0.5\ L/min$

$C_H^{IN} = 0.1\ mol/L$



@ $t = 0$

$V = 10L$

$C_Z = 1.0\ mol/L$

H = HYTREPHYL

Z = ZEFRON

J = JORKLBA

$$H + Z \rightarrow 2J$$

$$R_H = -0.06\, c_H$$

i) OVERALL MOLE BALANCE

$$ACC = IN - \cancel{OUT}^{\,0} + \cancel{GEN}^{\,0}$$

← NOTE THAT THE NUMBER OF MOLES CONSUMED = NUMBER OF MOLES GENERATED

$$\frac{d(cV)}{dt} = c^{IN} Q^{IN}$$

SINCE STREAMS ARE DILUTE

$$c^{IN} = c = c_{WATER}$$

SO, $\frac{dV}{dt} = Q^{IN}$

$$\boxed{\frac{dV}{dt} = 0.5}$$

INTEGRATING...

$$\boxed{V = 0.5t + 10}$$

V IS IN [L]
t IS IN [MIN]

@ $t = 10$ MIN $\underline{\underline{V = 15\,L}}$

ii) AMOUNT OF HYTREPHYL ADDED =

$$(10\ \text{min})(0.5\ \text{L/min})(0.1\ \text{mol/L}) = \underline{\underline{0.5\ \text{moles}}}$$

iii) HYTREPHYL MOLE BALANCE

$$ACC = IN - \cancel{OUT}^{0} + GEN$$

$$\frac{d(c_H V)}{dt} = c_H^{IN} Q^{IN} + R_H V$$

$$\frac{d(c_H V)}{dt} = (0.1)(0.5) - 0.06\, c_H V$$

$$V \frac{dc_H}{dt} + c_H \frac{dV}{dt} = 0.05 - 0.06\, c_H V$$

$$(0.5t+10)\frac{dc_H}{dt} + 0.5c_H = 0.05 - 0.06(0.5t+10)\,c_H$$

OR

$$\boxed{\frac{dc_H}{dt} + \left[\frac{0.5}{0.5t+10} + 0.06\right]c_H = \frac{0.05}{0.5t+10}}$$

iv) DIFF. EQ HAS FORM

$$\frac{dc_H}{dt} + a(t)\,c_H = f(t)$$

FIND INTEGRATING FACTOR

$$p(t) = e^{\int a(t)\,dt}$$

$$\rho(t) = e^{\int\left(\frac{0.5}{0.5t+10}+0.06\right)dt}$$

$$\int \frac{0.5}{0.5t+10}\,dt = \ln(0.5t+10)$$

$$\int 0.06\,dt = 0.06t$$

so $$\rho(t) = \exp\left[\ln(0.5t+10)+0.06t\right]$$

$$\rho(t) = (0.5t+10)\,e^{0.06t}$$

DIFF. EQN. BECOMES ...

$$\frac{d}{dt}\left[(0.5t+10)e^{0.06t}C_H\right] = \left(\frac{0.05}{0.5t+10}\right)(0.5t+10)e^{0.06t}$$

$$(0.5t+10)e^{0.06t}C_H = \int 0.05e^{0.06t}\,dt$$

$$= 0.833e^{0.06t} + 0.833C$$

$$C_H = \frac{0.833}{0.5t+10}\left[1 + Ce^{-0.06t}\right]$$

FIND CONSTANT OF INTEGRATION C...

INITIAL CONDITION... $@ t=0 \quad c_H = 0$

$$0 = \frac{0.833}{10}\left[1 + Ce^{0}\right]$$

SO $C = -1$

$$\boxed{C_H = \frac{0.833}{0.5t+10}\left[1 - e^{-0.06t}\right]}$$

v) AT $t = 10$ min

$$C_H = \frac{0.833}{0.5(10)+10}\left[1 - e^{-0.06(10)}\right]$$

$$= 0.0555\left[0.451\right]$$

$$C_H = 0.025 \text{ mol/L}$$

vi) AT $t = 10$ MIN $V = 15L$

$$C_H = 0.025 \text{ mol/L}$$

$$\text{THUS } n_H = (0.025 \text{ mol/L})(15L) = \underbrace{0.376 \text{ moles}}_{\text{THIS IS AMOUNT OF H REMAINING}}$$

$$\chi = \frac{\text{MOLES H CONS}}{\text{MOLES H FED}}$$

$$\chi = \frac{0.500 - 0.376}{0.500} = \boxed{24.9\%}$$

vii) AT $t = 10$ MIN

MOLES OF H CONSUMED $= 0.500 - 0.376$

$= 0.124$ moles H

$$0.124 \text{ moles H}_{\text{CONSUMED}} \times \frac{2 \text{ moles J GEN}}{\text{mol H CONS}} = 0.248 \text{ moles J}$$

$$C_J = \frac{0.248 \text{ moles}}{15 \text{ L}} = \underline{\underline{0.0166 \text{ mol/L}}}$$

viii) **HYTREPHYL MOLE BALANCE**

$Q^{IN} = 0$

$$ACC = \cancel{IN}^{0} - \cancel{OUT}^{0} + GEN$$

$$\frac{d(c_H V)}{dt} = V R_H$$

V IS NOW CONSTANT

$$\frac{dc_H}{dt} = -0.06\, c_H$$

$$c_H = C e^{-0.06t}$$

AT $t = 10$ min $\quad C_H = 0.025$ mol/L

SEE PART v) ABOVE

so $$0.025 = C e^{-0.06(10)}$$

$$C = 0.0456$$

$$\boxed{C_H = 0.0456 e^{-0.06t}}$$

AT $t = 20$ min $C_H = 0.0137$ mol/L

$$n_H = (15\,L)(0.0137\,\text{mol}/L) = 0.2059 \frac{\text{moles}}{L}$$

$$x = \frac{0.50 - 0.2059}{0.50} = \underline{\underline{58.8\%}}$$