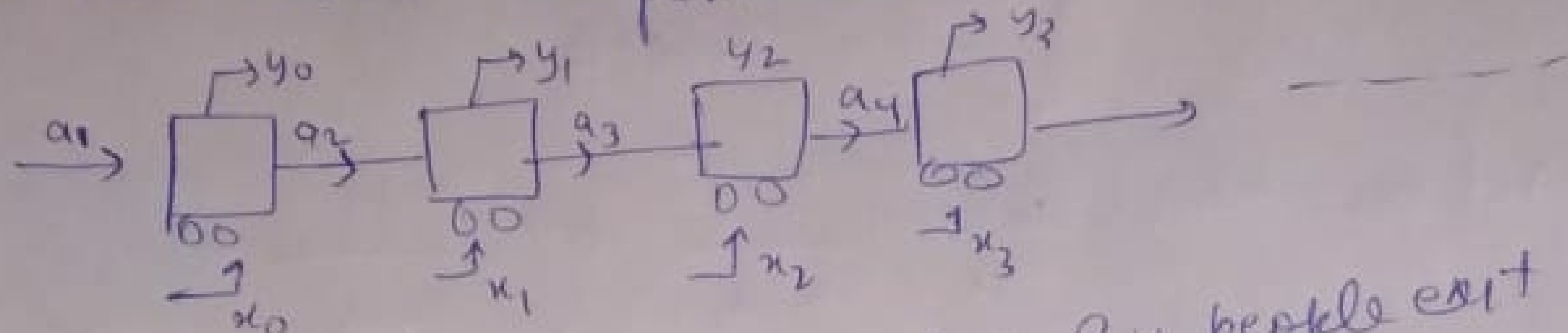
1) Assuming the system to be the whole train & the individual compartments as ~~sy~~ sub systems



At each compartment x people enter & y people exit & x & y are functions of time also

At a particular t for compartment k

~~xy~~ $x(t) - y(t) + a_{k-1} - a_{k+1} = N$ (no of people in compartment)

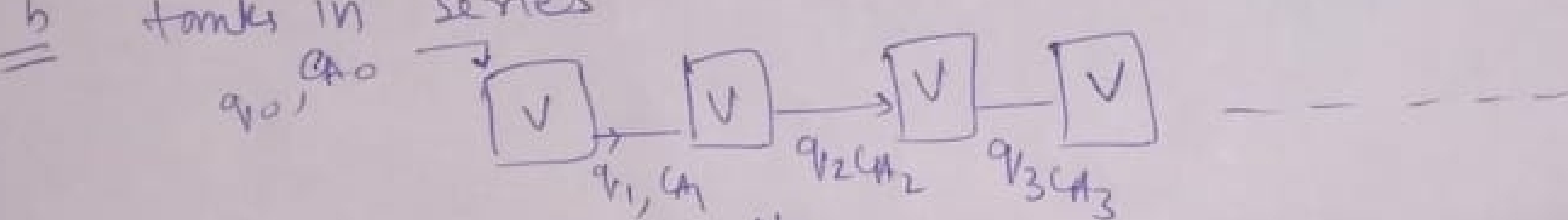
where a_{k-1}, a_{k+1} denote people crossing from compartments

where $k \to 1, 2, 3 \cdots n-1$

Degree of freedom $\Rightarrow$ No of unknown $-$ No of eq

$4 - 1 = \underline{\underline{3}}$

b tanks in series



let rxn be $A \to$ pdts.

so for ① $q_0 C_{A0} - q_1 C_{A1} - k C_{A1} V = V \frac{dC_{A1}}{dt}$

general balance for i^{th} reactor

$$\boxed{q_{i-1} C_{A_{i-1}} - q_i C_{A_i} - k C_{A_i} V = V \frac{dC_{A_i}}{dt}}$$

for energy balance

$(q_{i-1} C_{A_{i-1}}) H_{A_{i-1}} - (q_i C_{A_i}) H_{A_i} =$ Net enthalpy of compartment i.

Similarities

→ Both train & tank models have separate unit compartments linked in series where material travel from one to the other subsystem

→ Materials balances can be applied in both cases as mass/energy remains conserved.

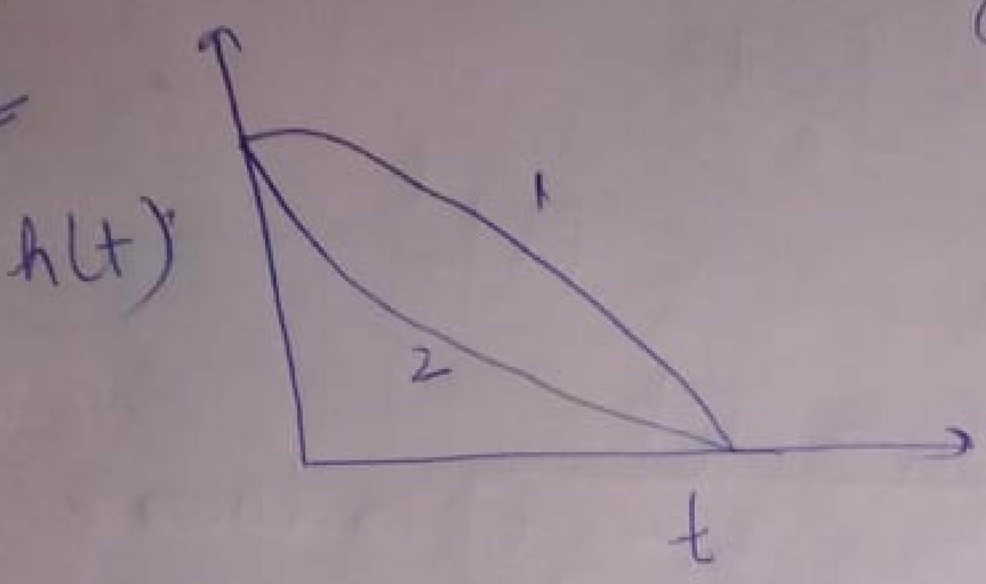
Differences

→ In train, people can move out & in simultaneously while in tank reactors, it moves in one direction

→ In train, people donot affect the movement of others i.e.. where to depart or board. In case of reactors the conversion and concentration entering or leaving depends on rate, energy & temperature etc.

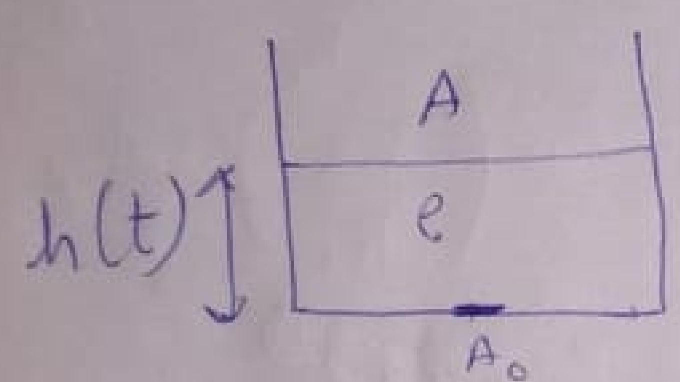
(2)

a



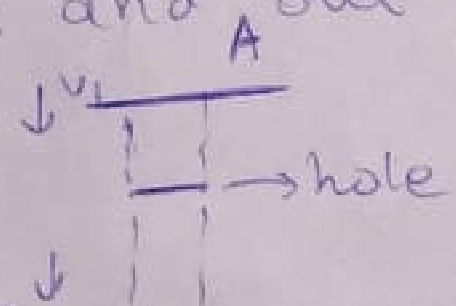
Choice 2 seems correct as the slope decreases in (2) & slope $= dh/dt =$ velocity must decrease as pressure difference will decrease as height falls.

b



Assuming density to be constant we apply mass balance on water coming out at the juncture

Our control volume would be the hole area along with small section in and out of the hole



Since mass is conserved, mass in $-$ mass out $= 0$

(amount of liquid out of hole = amount of liquid from bulk to hole)

mass in $\Rightarrow (A \times v_1)\rho$

mass out $\Rightarrow (A_0 \times v_2)\rho$

$$A v_1 \cancel{\rho} = A_0 v_2 \cancel{\rho}$$

$$\boxed{A v_1 = A_0 v_2}$$

Principle of continuity

(c) 1) $q = c$

$$\frac{dh}{dt} = \frac{c}{A} \Rightarrow \int dh = \int \frac{c}{A} dt$$

$$|h|_{h_1}^{h_2} = \frac{c}{A} |t|_0^t$$

$$-h_2 + h_1 = \frac{ct}{A}$$

$$\boxed{h_2 = h_1 - \frac{ct}{A}} \rightarrow \text{linear}$$

2) $q = h(t)$

$$\frac{dh}{dt} = -\frac{h(t)}{A} \qquad \int \frac{dh}{h} = -\int \frac{dt}{A} \Rightarrow \ln|h|_{h_1}^{h_2} = -\left|\frac{t}{A}\right|_0^t$$

$$\ln\left(\frac{h_2}{h_1}\right) = -t/A$$

$$\boxed{h_2 = h e^{-t/A}}$$

c) $q = kh^n$

$$\frac{dh}{dt} = -kh^n \Rightarrow \int_{h_0}^{h(t)} h^{-n} dh = -\int_0^t \frac{k}{A} dt$$

$$\left[\frac{h^{-n+1}}{-n+1} - \frac{h_0^{-n+1}}{-n+1}\right] = -kt/A$$

$$\boxed{h(t) = \left[(1-n)\left[\frac{h_0^{1-n}}{1-n} - \frac{kt}{A}\right]\right]^{1/1-n}}$$

Not applicable for $n=1$ as for that we donot get the lograthmic term & integration will give another result., the correct result for it is given in (2). For $n=1$, graph is ~~lograt~~ exponential in power of e, not obtained in curve in expression (3).

take log

$$\log(h(t)) = \frac{1}{1-n}\left[\log\left((1-n)\left[\frac{h_0^{1-n}}{1-n} - \frac{kt}{A}\right]\right)\right]$$

for $n>1$. $1-n<0$

$$\log(h(t)) = -\frac{1}{n-1}\log\left[(n-1)\left[\frac{1}{(n-1)h_0^{n-1}} + \frac{kt}{A}\right]\right]$$

As we see as $t\uparrow$, log term increases and ~~log(h(t)) is negative~~ RHS increases, so $h(t)$ decreases as RHS is negative

for $n<1$

$$\log(h(t)) = \frac{1}{1-n}\log\left[(1-n)\left[\frac{h_0^{1-n}}{1-n} - \frac{kt}{A}\right]\right]$$

As $t\uparrow$, log term decreases and since RHS is positive $\log(h(t))$ decreases, so $h(t)$ decreases.

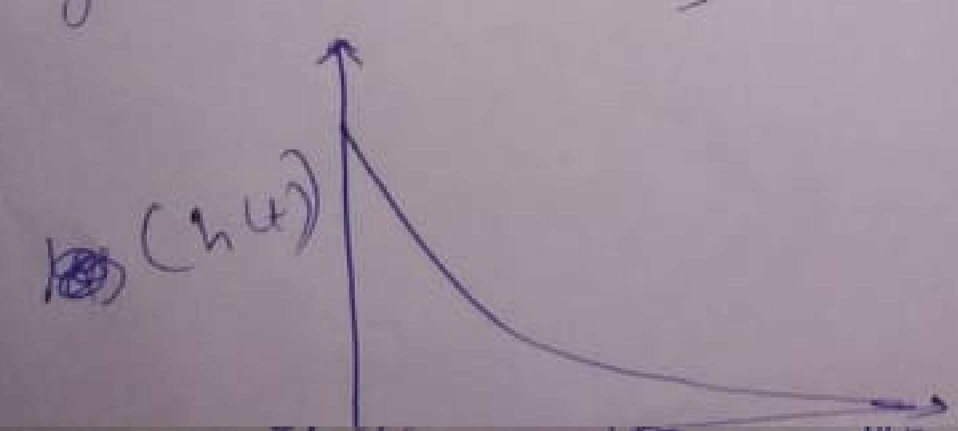
for $n>1$

$$\frac{1}{h}\frac{dh}{dt} = -\frac{1}{(n-1)}\frac{1}{(n-1)\left[\frac{1}{(n-1)h_0^{n-1}} + \frac{kt}{A}\right]}\cdot\frac{(n-1)k}{A}$$

All the term on RHS are positive so $\frac{dh}{dt}<0$

as $t\uparrow$, $\frac{kt}{A}\uparrow$ & denominator $\uparrow$, so overall fraction decreases

Therefore as $t\uparrow$, slope is decreasing

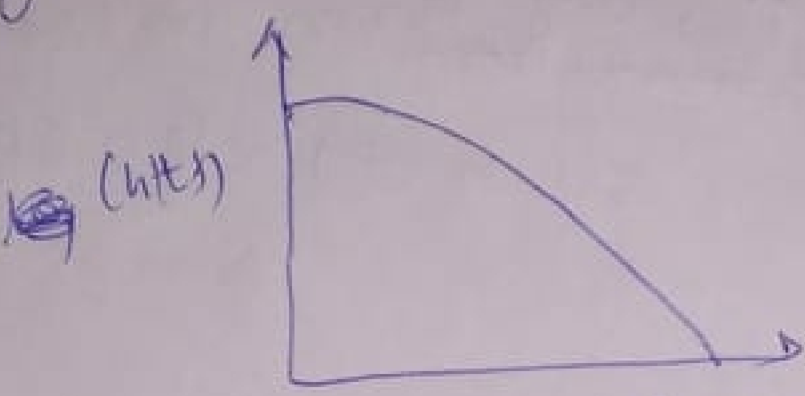


for $n<1$

$$\frac{1}{h}\frac{dh}{dt} = \frac{1}{(1-n)} \frac{1}{(1-n)\left[\frac{h_0^{1-n}}{(1-n)} - \frac{kt}{A}\right]} \xrightarrow{} -(1-n)k/A$$

All term on LHS are positive, so $\frac{dh}{dt} < 0$

As $t \uparrow$, $\frac{kt}{A}$ increases and denominator decreases so overall fraction increases, so $\frac{dh}{dt}$ increases.



So for $n=1$ the curve fits better.

d) for run 1 eq ⇒ ~~y = ...~~

$$y = -8.113 - 0.117x + 0.0003x^2 + 6.22\times10^{-7}x^3$$

run 2 eq $y = 8.071 - 0.159x + 0.0011x^2 - 0.0000003x^3$

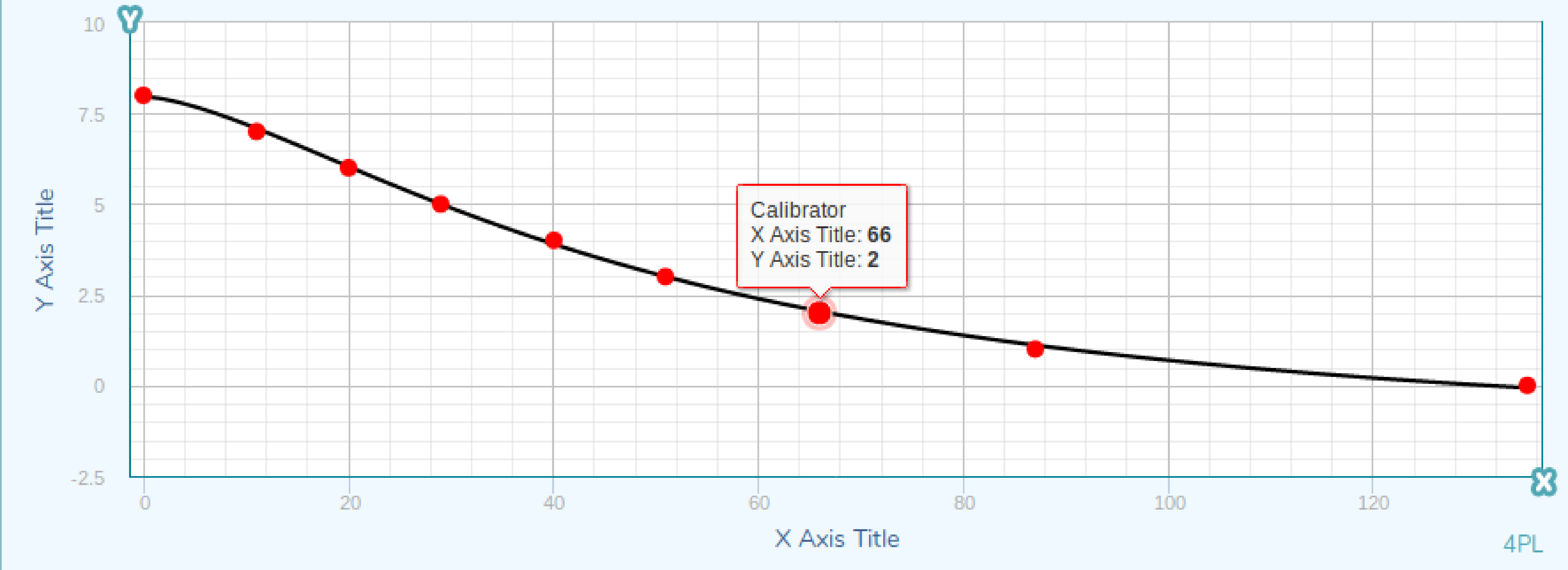
run 3 eq $y = 8.08 - 0.1328x + 0.0006x^2 - 4.814\times10^{-7}x^3$

fitting an exponential curve

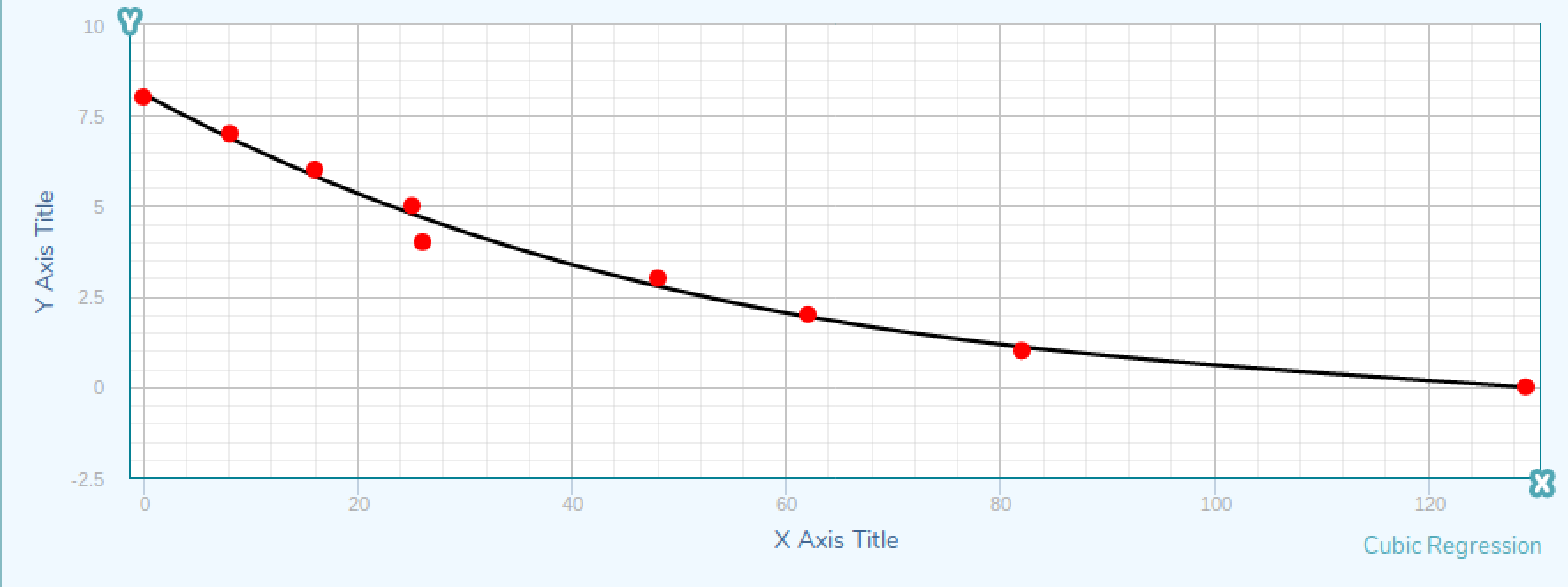
$$y = -1.288 + 9.484e^{-0.0162x}$$

So comparing $1/A = 0.0162$

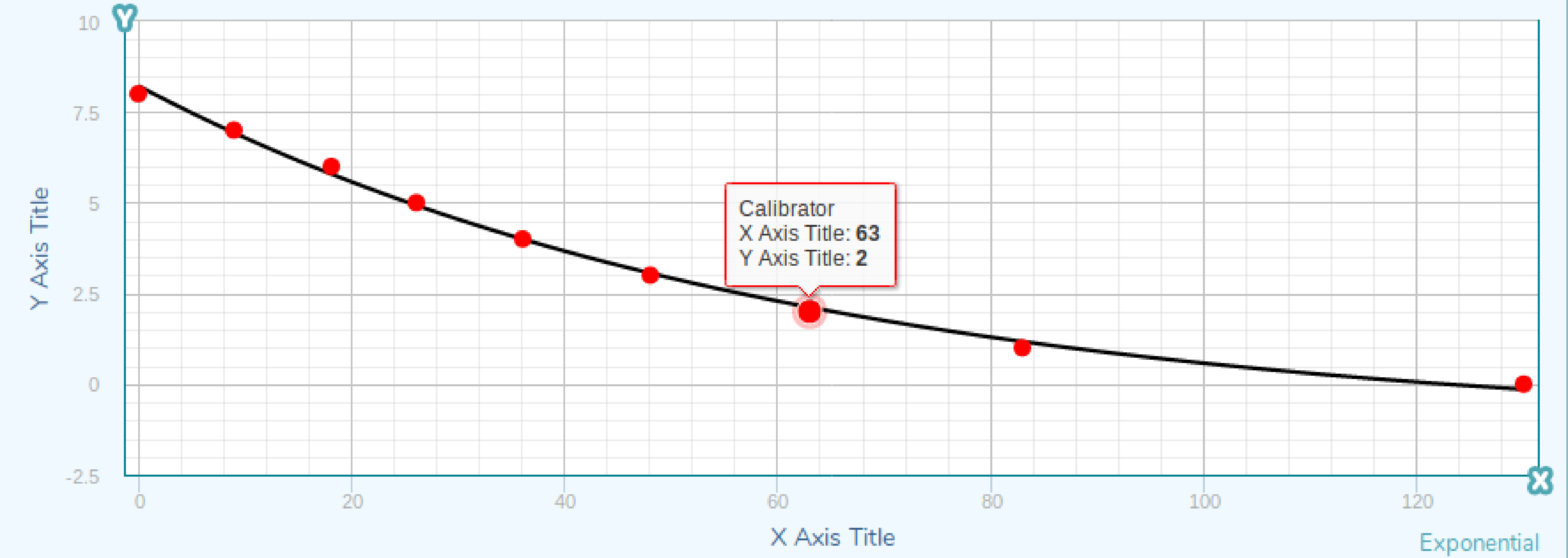
$A = 61.7 m^2$



Calibrator
X Axis Title: 66
Y Axis Title: 2
10
7.5
5
2.5
0
-2.5
0
20
40
60
80
100
120
Y Axis Title
X Axis Title
4PL



10
7.5
5
2.5
0
-2.5
0
20
40
60
80
100
120
Y Axis Title
X Axis Title
Cubic Regression



10
7.5
5
2.5
0
-2.5
0
20
40
60
80
100
120
Y Axis Title
X Axis Title
Calibrator
X Axis Title: 63
Y Axis Title: 2
Exponential

Reasons for variance in experimental data

→ human error while calculating the heights at different time interval.

→ instrumental errors (stop watch, measuring cylinder etc)

→ expansion ~~or~~ of water may lead to faulty readings

For the system, parameters are $\rho, A, A_o, \mu, h, g, v$

Assuming no density variation, g is constant.
(ρ will get cancelled so no need)

For no viscosity

$q = L^3 T^{-1}$ $\quad A_o = L^2$ $\quad$ ~~A = L^2~~

$h = L$ $\quad g = LT^{-2}$

no of dimensionless group = $4 - 2 = 2$

2 groups (dimensionless) formed are

→ $\frac{A_o}{h^2}, \frac{q^2}{g A_o^2 h}$

So we can write them as function of other

$$f\left(\frac{A_o}{h^2}\right) = \frac{q^2}{g A_o^2 h}$$

If hole is small $A_o/h^2 \to 0$, thus value of function will lead to $f(0)$ which will be a constant value

So $\frac{q^2}{g A_o^2 h} = c$ for $A_o/h^2 \to 0$

$$q^2 = c g A_0^2 h$$

$$q = C A_0 \sqrt{gh} \Rightarrow$$

$$\Rightarrow q \propto \sqrt{gh} \Rightarrow q \propto h^n$$

here $n = 1.41 > 1$

Hence verified what we found before where $n > 1$ for right results

) for consideration with viscosity

variable = ρ, μ, g, h, A_0, q

dimensionless groups = $6 - 3 = 3$

$$\mu = ML^{-1}T^{-1}$$

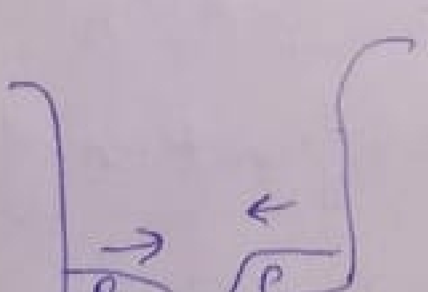
$$\rho = ML^{-3}$$

dimensionless no can be $\Rightarrow \dfrac{\rho q}{\mu h} \Big| \dfrac{\rho}{\mu} \times \dfrac{q}{\sqrt{A_0}}$

$$f\left(\frac{A_0}{h^2}, \frac{\rho}{\mu}\frac{q}{\sqrt{A_0}}\right) = \frac{q^2}{g A_0^2 h}$$

ere if $\dfrac{A_0}{h^2}$ is not $\to 0$ as $h \downarrow$ & become very less

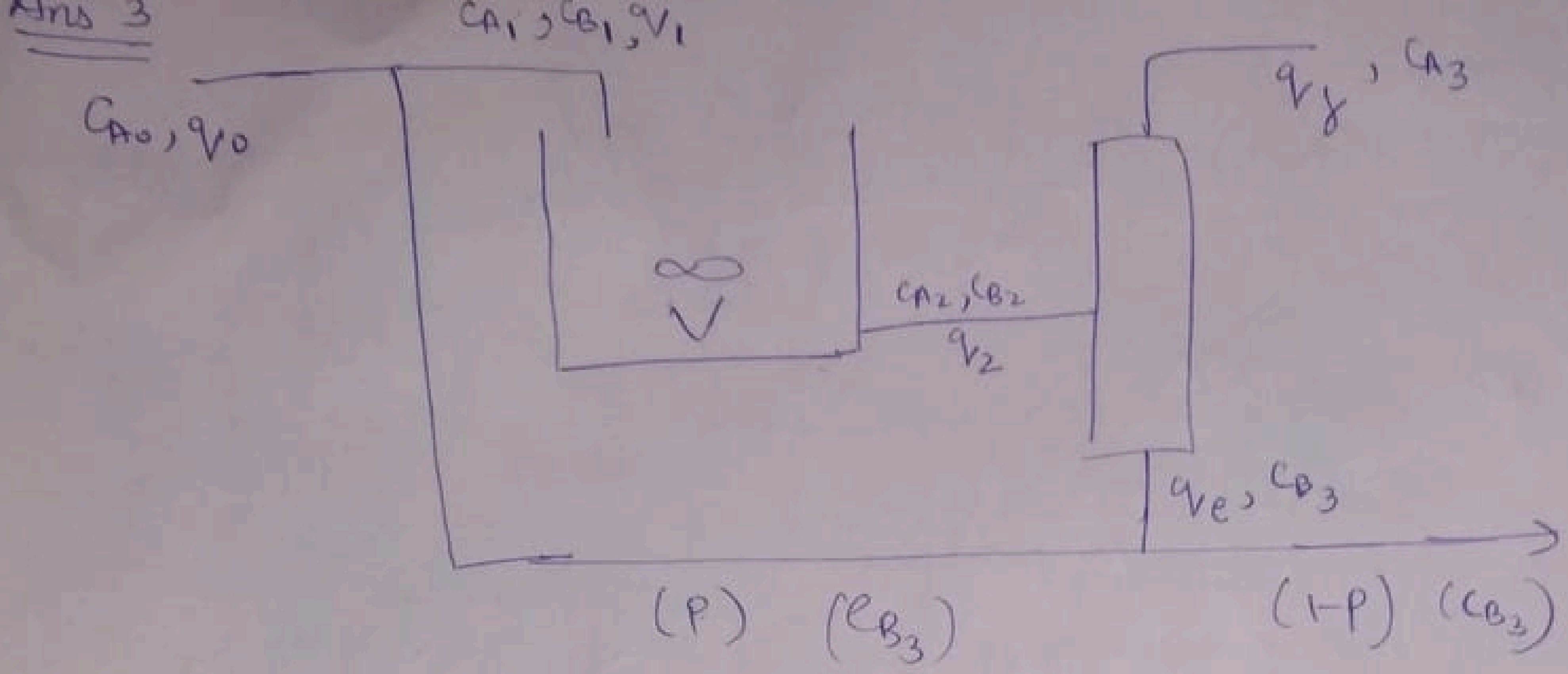
so



Here $P > P_{atm}$ so at hole the height will be a function of x, t i.e., $h(x, t)$

so applying Bernoulli we need 2 parameters of x, t.

Ans 3



Rxn → $A + \beta B \rightarrow \gamma B \qquad \gamma > \beta$

$r = k C_A C_B$

given parameters → C_{A_0}, V, q_1, q_2, P

Balances

$$C_{A_1} q_1 - q_2 C_{A_2} - k C_{A_2} C_{B_2} V = 0 \quad (1)$$

$$C_{B_1} q_1 - q_2 C_{B_2} - k C_{A_2} C_{B_2} (\beta - \gamma) = 0 \quad (2)$$

$$q_2 C_{B_2} = q_e C_{B_3} \quad (3) \qquad q_2 C_{A_2} = q_\gamma C_{A_3} \quad (4)$$

$$q_2 = q_e + q_\gamma \quad (5)$$

Also

$$q_1 C_{B_1} = P \cdot q_2 C_{B_2} \quad (6)$$

Put (6) in (2)

$$P q_2 \cancel{C_{B_2}} - q_2 \cancel{C_{B_2}} - k C_{A_2} \cancel{C_{B_2}} V (\beta - \gamma) = 0$$

$$P q_2 - q_2 - k C_{A_2} V (\beta - \gamma) = 0$$

$$\boxed{C_{A_2} = \frac{q_2 (P-1)}{V k (\beta - \gamma)}}$$

from ①
$$C_{A_1}q_1 - q_2\left[\frac{q_2(\rho-1)}{VK(\beta-\gamma)}\right] - KV\left[\frac{q_2(\rho-1)}{VK(\beta-\gamma)}\right]C_{B_2} = 0$$

$$\frac{C_{A_1}q_1}{q_2\left[\frac{q_2(\rho-1)}{VK(\beta-\gamma)}\right]} = 1 + KV C_{B_2}$$

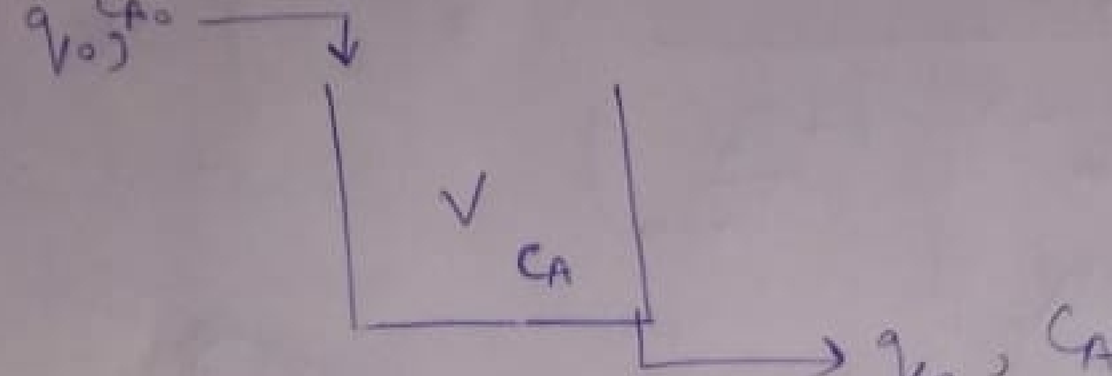
$$\frac{C_{A_1}q_1 - \frac{q_2^2(\rho-1)}{VK(\beta-\gamma)}}{\frac{q_2^2(\rho-1)}{VK(\beta-\gamma)} \times KV} = C_{B_2} \quad \boxed{C_{B_2} \Rightarrow \frac{C_{A_1}q_1 VK(\beta-\gamma) - q_2^2(-\rho+1)}{KV q_2^2(-\rho+1)}}$$

$$C_{B_2}\ (\text{exiting CSTR}) = \frac{C_{A_1}q_1 VK(\beta-\gamma) - q_2^2(-\rho+1)}{KV q_2^2(-\rho+1)}$$

$$C_{B_3} = \frac{q_2 C_{B_2}}{q_e} = \frac{C_{A_1}q_1 VK(\beta-\gamma) - q_2^2(-\rho+1)}{KV q_2^2(-\rho+1)\cdot q_e}$$ (assuming q_e is given).

Ans 4

$A \longrightarrow \text{Pdts}$ rate $= KC_A$



Applying Material Balance ⇒ in − out + rate of dissapearance = rate of accum^n

$$q_0 C_{A0} - q_e C_A - K C_A V = \frac{d(V C_A)}{dt}$$ (for unsteady state)

Assuming V to be constant

$$q_0 C_{A0} - q_e C_A - K C_A V = -\frac{V\, dC_A}{dt}$$

Let the conversion be x

$$C_A = C_{A0}(1-x)$$

$$q_0 \cancel{C_{A0}} - q_e \cancel{C_{A0}}(1-x) - K\cancel{C_{A0}}(1-x)V = \frac{-V\, d(\cancel{C_{A0}}(1-x))}{dt}$$

$$q_0 - q_e(1-x) - k(1-x)V = V\frac{dx}{dt}$$

Assuming $q_0 = q_e$

$$\cancel{q_0} - \cancel{q_0} + q_0 x - kV(1-x) = V\frac{dx}{dt}$$

$$x - k\frac{V}{q_0}(1-x) = \frac{V}{q_0}\frac{dx}{dt}$$

let $\frac{V}{q_0} = \tau_h$ $\quad 1/k = \tau_{rxn}$

$$\boxed{-x + \frac{\tau_h}{\tau_{rxn}}(1-x) = \tau_h \frac{dx}{dt}}$$

$$\frac{\tau_h}{\tau_{rxn}} - X\left(1+\frac{\tau_h}{\tau_{rxn}}\right) = \tau_h\frac{dX}{dt}$$

$$\int_0^X \frac{\tau_h\, dX}{\frac{\tau_h}{\tau_{rxn}} - X\left(1+\frac{\tau_h}{\tau_{rxn}}\right)} = \int_0^t dt$$

let $\left(1+\frac{\tau_{rxn}}{\tau_h}\right)X = P$

$\left(1+\frac{\tau_{rxn}}{\tau_h}\right)dX = dP \Rightarrow$

$$\tau_{rxn}\int_0^X \frac{dX}{1 - X\left(1+\frac{\tau_{rxn}}{\tau_h}\right)} = \frac{\tau_{rxn}}{1+\frac{\tau_{rxn}}{\tau_h}}\int \frac{dP}{1-P}$$

On solving

$$\Rightarrow -\frac{\tau_{rxn}}{1+\frac{\tau_{rxn}}{\tau_h}} \ln\left[1 - X\left(1+\frac{\tau_{rxn}}{\tau_h}\right)\right] = t$$

$$\boxed{X(t) = \frac{1-\exp\left[-t\left(\frac{1}{\tau_{rxn}}+\frac{1}{\tau_h}\right)\right]}{\tau_{rxn}\left[\frac{1}{\tau_{rxn}}+\frac{1}{\tau_h}\right]}}$$

steady state at $t \to \infty$

$$X(t)_{ss} = \frac{1-\overbrace{\exp\left[-t\left(\frac{1}{\tau_{rxn}}+\frac{1}{\tau_h}\right)\right]}^{\to 0}}{\tau_{rxn}\left(\frac{1}{\tau_{rxn}}+\frac{1}{\tau_h}\right)} = \frac{1}{\tau_{rxn}\left[\frac{1}{\tau_{rxn}}+\frac{1}{\tau_h}\right]}$$

Rxn time scale $\Rightarrow \tau_{rxn} = 1/k$

hydraulic time scale $= \tau_h = V/q$

time scale for steady state = $\tau = \dfrac{1}{\frac{1}{\tau_{rxn}} + \frac{1}{\tau_h}}$

Significance

τ_{rxn} denote fastness of rxn occurence

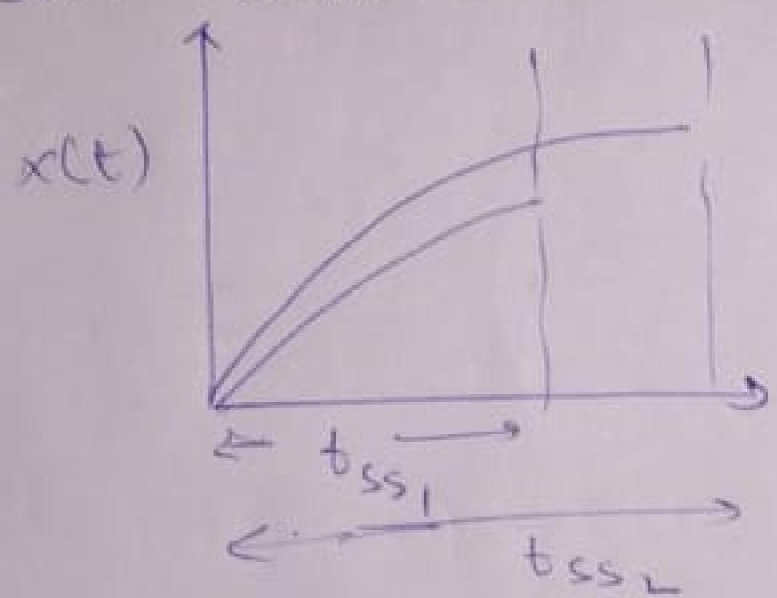
τ_h denotes the time of stay or physical time taken within reactor by reactant.

If $\tau_h \uparrow$, $\tau \uparrow$

$\tau_{rxn} \uparrow$, $\tau \uparrow$

so steady state achieve will be late

If τ_h increases, stay time increases, steady state occur late but conversion is more



If $\tau_{rxn} \uparrow$, reaction gets slowed

5)

$$A+B \xrightarrow{k} C$$

In presence of light $r = k_{ON} C_A C_B$

In absence of light $r = k_{off} C_A C_B$

finding X_1 first

$$\frac{dC_A}{dt} = k_{ON} C_{A0}(1-X)(C_{B0} - C_{A0}X)$$

$$C_{A0} \frac{dX_A}{dt} = k_{ON} \cancel{C_{A0}} (1-X)(C_{B0} - C_{A0}X)$$

$$\frac{dX_A}{dt} = k_{ON} (1-X) C_{A0} (M - X)$$

where $M = C_{B0}/C_{A0}$

$$\int_0^X \frac{dX}{(1-X)(M-X)} = \frac{k_{ON} C_{A0}}{} \int_0^{ZON} dt$$

$$\frac{1}{(M-1)} \int \frac{1}{1-X} - \frac{1}{M-X} \Rightarrow \left(\frac{1}{M-1}\right)\left[\int \frac{1}{1-X} - \int \frac{1}{M-X}\right]$$

$$\Rightarrow \frac{1}{M-1}\left[-\ln(1-X) + \ln(M-X)\right]$$

$$\frac{1}{M-1}\left[\ln\left(\frac{M-X}{1-X}\right)\right]_0^X = k_{ON} C_{A0} t$$

$$\ln\left(\frac{M-X}{1-X}\right)_{X_1}^{X_2} = (M-1) k_{ON} C_{A0} t$$ Putting $X_1 = 0$

$$\boxed{Z_{ON} = \frac{1}{k_{ON} C_{A0} (M-1)} \ln\left[\frac{M - X_{A_1}}{M(1-X_{A_1})}\right]}$$

Now C_{A_0} left $= C_A(1-X_{A_1})$ $\quad C_{B_{0_2}} = C_{B_0} - C_{A_0}X_{A_1}$

New conversion $= X_{A_2}$

$$r = k_{off}\, C_{A_{0_2}}(1-X)\left(C_{B_{0_2}} - C_{A_0}X_{A_1} - C_{A_{0_2}}X\right)$$

$$= \underbrace{k_{off}\, C_{A_0}(1-X_{A_1})}_{N}(1-X)\left(\underbrace{C_{B_0} - C_{A_0}X_{A_1}}_{P} - C_{A_0}(1-X_{A_1})X\right)$$

$$\cancel{r = \frac{k_{off}\, C_{A_0}^2(1-X_{A_1})(1-X)}{C_{A_0}(1-X_{A_1})}\left(\frac{C_{B_0}-C_{A_0}X_{A_1}}{C_{A_0}(1-X_{A_1})} - X\right)}$$

$$r = k_{off}(1-X)(M-X)$$

$$\frac{dX}{dt} = \underbrace{k_{off}\,(C_{A_0}(1-X_1))}_{N}(1-X)\left(\underbrace{\frac{C_{B_0}-C_{A_0}X_{A_1}}{C_{A_0}(1-X_{A_1})}}_{M} - X\right)$$

$$\frac{dX}{dt} = N(1-X)(M-X)$$

$$\int_{X_1}^{X_2}\frac{dX}{(1-X)(M-X)} = \int Nt \Rightarrow \cancel{\ln\left(\frac{M-X_2}{M(1-X_2)}\right) = (M-1)\,N\,t_{off}}$$

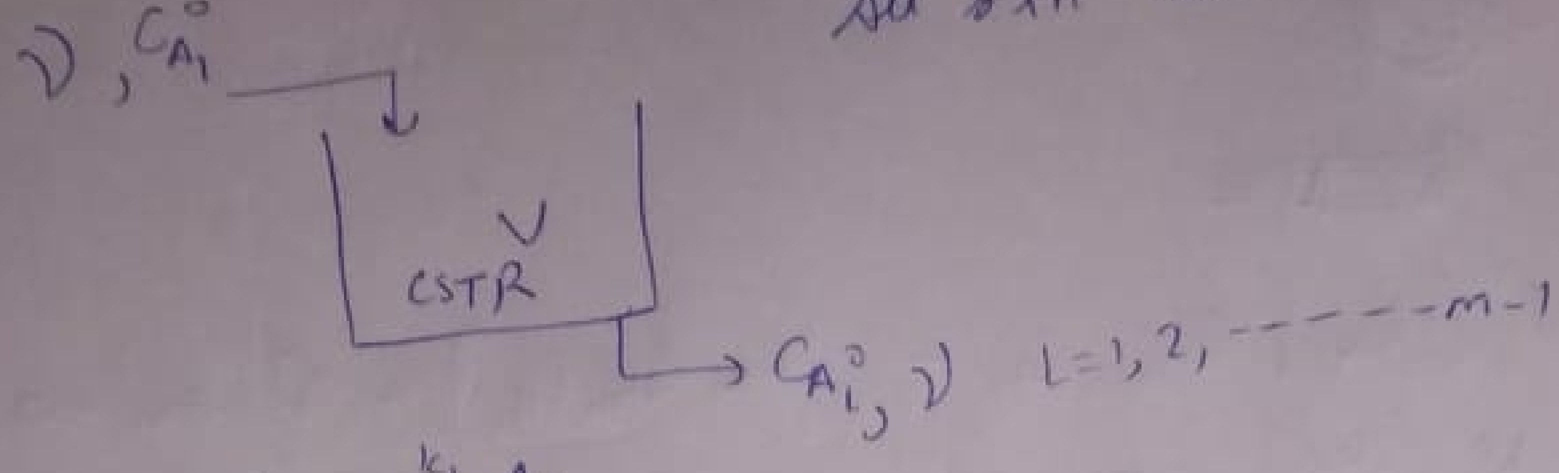
$$\boxed{t_{off} = \frac{1}{k_{off}\, C_{A_0}(1-X_{A_1})} \times \frac{1}{(M-1)}\ln\left[\frac{M-X_{A_2}}{M-X_{A_1}} \times \frac{1-X_{A_1}}{1-X_{A_2}}\right]}$$

$$t_{ON_2} = \frac{1}{k_{ON}\, C_{A_0}(1-X_{A_1})(1-X_{A_2})(M-1)}\ln\left[\frac{M-X_{A_3}}{M-X_{A_2}} \times \frac{1-X_{A_2}}{1-X_{A_3}}\right]$$

$$t_{off_2} = \frac{1}{k_{off}\, C_{A_0}(1-X_{A_1})(1-X_{A_2})(1-X_{A_3})(M-1)}\ln\left[\frac{M-X_{A_4}}{M-X_{A_3}} \times \frac{1-X_{A_3}}{1-X_{A_4}}\right]$$

$$\tau_{total} = \tau_{ON_1} + \tau_{off_1} + \tau_{on_2} + \tau_{off_2} - - -$$

(6) All rxn are elementary



$$A_1 + A_1 \xrightarrow{k_1} A_2$$
$$A_2 + A_1 \xrightarrow{k_2} A_3$$
$$A_3 + A_1 \xrightarrow{k_3} A_4$$
$$\vdots \quad \vdots \quad \vdots$$

Balance $A_1 \rightarrow$
$$\nu C_{A_1}^{0} - \nu C_{A_1} \left(- k_1 C_{A_1}^2 - k_2 C_{A_1} C_{A_2} - k_3 C_{A_1} C_{A_3} \right) V = 0$$
$$\vdots \quad \vdots \quad \vdots$$

$$A_2 \rightarrow V \left(k_1 C_{A_1}^2 - k_2 C_{A_1} C_{A_2} \right) = 0$$

General
$$V \left[k_{m-1} C_{A_{m-1}} C_{A_1} - k_m C_{A_m} C_{A_1} \right] - \nu C_{A_m} = 0$$
(Not for A_1)

for $A_1 \rightarrow \nu C_{A_1}^{0} - \nu C_{A_1} - V \left(k_1 C_{A_1}^2 + k_2 C_{A_1} C_{A_2} \ldots \right) = 0$

for $A_{last} \rightarrow -\nu C_{A_m} + V k_{m-1} C_{A_1} C_{A_{m-1}} = 0$

for all $A_m \rightarrow V \left[k_{m-1} C_{A_{m-1}} C_{A_1} - k_m C_{A_m} C_{A_1} \right] - \nu C_{A_m} = 0$

Overall Mass balance Mass in $= \left(\nu C_{A_1}^{0} \right) \times M_1$ (M_1 is molar mass of A_1)

Mass out $= \nu \left[C_{A_1} M_1 + C_{A_2} M_2 + C_{A_3} M_3 \ldots\ldots \right]$

$$C_{A_1}^{0} M = C_{A_1} M_1 + C_{A_2} M_2 \ldots\ldots C_{A_m} M_m$$

$\boxed{\text{where } M_i = i \times M}$

$\Rightarrow C_{A_1}^{\circ} \cancel{M_1} = C_{A_1} \times \cancel{M_1} + 2C_{A_2}\cancel{M_1} + 3C_{A_3}\cancel{M_1} ----$

$C_{A_1}^{\circ} = C_{A_1} + 2C_{A_2} + 3C_{A_3} ------$

$$\boxed{C_{A_1}^{\circ} = \sum_{i=1}^{i=m} i\, C_{A_i}}$$

c from eq ②

$$\frac{VK_{m-1} C_{A_{m-1}} C_{A_1}}{VK_m C_{A_1} + \nu} \Rightarrow \frac{\frac{VK}{m-1} \frac{C_{A_{m-1}}}{C_{A_1}^{\circ}} \frac{C_{A_1}}{C_{A_1}^{\circ}}}{\frac{VK}{m} \frac{C_{A_1}}{C_{A_1}^{\circ 2}} + \frac{\nu}{C_{A_1}^{\circ 2}}}$$

$$\Rightarrow \left(\frac{VK}{m-1} \hat{C}_{A_{m-1}} \hat{C}_{A_1}\right) \Big/ \left(\frac{VK}{m} \frac{\hat{C}_{A_1}}{C_{A_1}^{\circ}} + \frac{\nu}{C_{A_1}^{\circ 2}}\right)$$

$$\boxed{\eta = \frac{VK}{\nu}}$$

$$\frac{\left(\frac{VK}{\nu}\right)\left(\frac{\hat{C}_{A_{m-1}} \hat{C}_{A_1}}{m-1}\right)}{\left(\frac{VK}{\nu}\right)\frac{\hat{C}_{A_1}}{m C_{A_1}^{\circ}} + \frac{1}{C_{A_1}^{\circ 2}}} = \frac{\eta\left[\frac{\hat{C}_{A_{m-1}} \hat{C}_{A_1}}{m-1}\right]}{\frac{1}{C_{A_1}^{\circ 2}}\left[1 + \eta \frac{\hat{C}_{A_1} C_{A_1}^{\circ}}{m}\right]}$$

$$\boxed{\hat{C}_{A_m} = \frac{\left[\frac{\hat{C}_{A_{m-1}} \hat{C}_{A_1}}{m-1}\right]}{\frac{1}{C_{A_1}^{\circ}}\left[\frac{1}{\eta} + \frac{\hat{C}_{A_1} C_{A_1}^{\circ}}{m}\right]}}$$

d for $\eta \ll 1$, $\frac{1}{\eta} \gg \frac{\hat{C}_{A_1} C_{A_1}^{\circ}}{m}$

$$\boxed{\hat{C}_{A_i} = \left(\frac{\hat{C}_{A_{m-1}} \hat{C}_{A_1}}{m-1}\right) \eta\, C_{A_1}^{\circ}}$$

$\eta \gg 1$ $\frac{1}{\eta} \ll \frac{\hat{C}_{A_1} C_{A_1}^{\circ}}{m}$

$$\hat{C}_{A_i} = \left(\frac{\hat{C}_{A_{m-1}} \hat{C}_{A_1}}{m-1}\right) \Big/ \frac{\hat{C}_{A_1}}{m}$$

$$\boxed{= \frac{(\hat{C}_{A_{m-1}})\, m}{(m-1)}}$$

This is of the form of

$$\frac{a}{(m-1)\left(\frac{1}{\eta}+\frac{b}{m}\right]} = \hat{C}_A$$

$$\frac{m-1}{\frac{a}{C_A}-\left(1-\frac{1}{m}\right)b} = \eta$$ (knowing η we can find m; we need to know $V, \mathcal{D}, K$)

If $m\uparrow$, numerator $\uparrow$ & denominator $\downarrow$ so $\eta\uparrow$

So $\boxed{\eta \propto m}$

So greater value of η ($\eta >> 1$) is giving more $\underline{m}$.

Significance.

$\eta = \frac{KV}{\mathcal{D}} \Rightarrow (V/\mathcal{D})/(1/K)$ → this is the ratio of ~~reaction~~ hydraulic time scale to reaction time scale

thus if $\eta > 1$, hydraulic time scale > reaction time scale & vice versa

7) $A + B \rightarrow AB$

C_{A0} C_{B0}

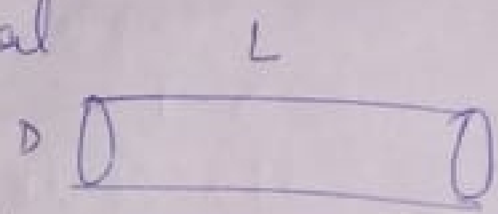
$$-r = K C_A C_B$$

Reaction time scale = $\frac{1}{K C_{Ai}}$ or $\frac{1}{K C_{Bi}}$

depending on which is limiting reagent

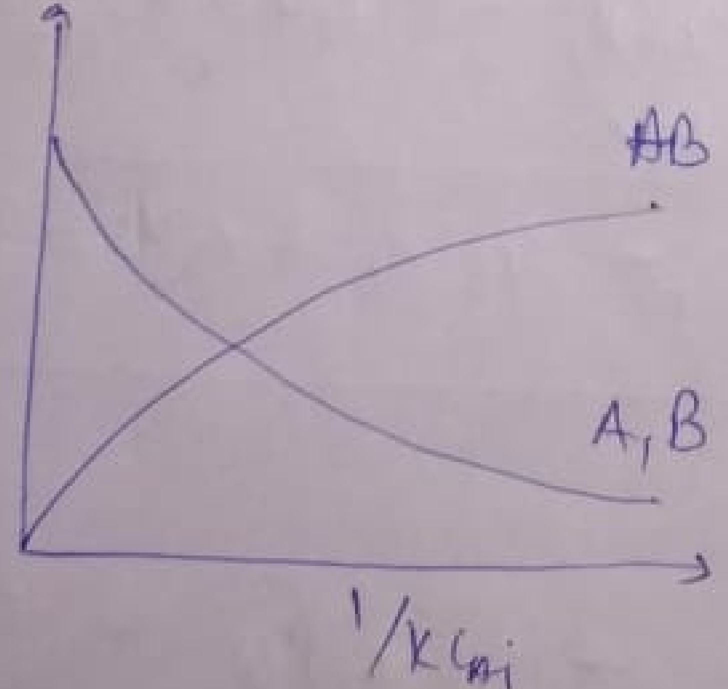
Length scale = diameter or free mean path
(this is the min distance the particle travel to collide & interact)

Since particles are spherical

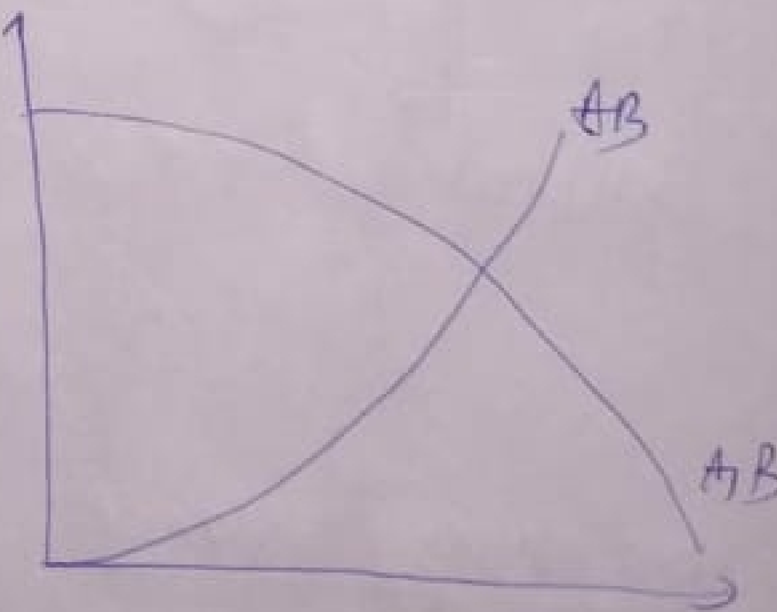


the diameter of vessel must be equal to or greater than free mean path or length scale defined above as the lower range for D & L

Dimensionless time = $t / \frac{1}{K C_{Ai}}$



fast



slow.