CMBR

$$V\frac{dc}{dt} = C_0 Q - CQ + Vr$$

$$Q = 0$$

$$V\left(\frac{dc}{dt}\right) = C_0(0) - C(0) + Vr$$

$$r = \frac{dc}{dt}$$

1st order:

$$r = -KC$$

$$\frac{dc}{dt} = -KC$$

$$\int_{C_0}^{C} \frac{dc}{c} = -K\int_0^t dt$$

$$\ln(C)_{C_0}^{C} = -K[t]_0^t$$

$$\ln C - \ln C_0 = -Kt$$

$$\ln\left[\frac{C}{C_0}\right] = -Kt$$

$$\frac{C}{C_0} = e^{-Kt}$$

$$\boxed{C = C_0 e^{-Kt}}$$

CSTR

$$V\frac{dc}{dt} = QC_0 - QC + Vr$$

$$\frac{dc}{dt} = \frac{Q(C_0 - C)}{V} + r$$

$$\frac{dc}{dt} = 0$$

$$0 = \frac{Q(C_0 - C)}{V} + r \qquad Q = \frac{V}{t}$$

$$r = -\frac{(C_0 - C)}{t} \qquad t = \frac{V}{Q}$$

1st order

$$r = -KC$$

$$-\frac{(C_0 - C)}{t} = -KC$$

$$\frac{C_0 - C}{C} = Kt$$

$$\frac{C_0}{C} - \frac{C}{C} = Kt$$

$$\frac{C_0}{C} - 1 = Kt$$

$$\frac{C_0}{C} = Kt + 1$$

$$C = \frac{C_0}{1 + Kt}$$

PFR

Same as CMBR

Numericals

0 order = $C = C_0 - Kt$
$5 = 100 - K(1)$
$K = 95$ mg/l/hr

1st order = $C = C_0 e^{-Kt}$
$K = 3$ mg/l/hr

Data:
$C_0 = 100$ mg/L
$C = 5$ mg/L
$t = 1$ hr
i) 1st $K = ?$
ii) zero order $K = ?$

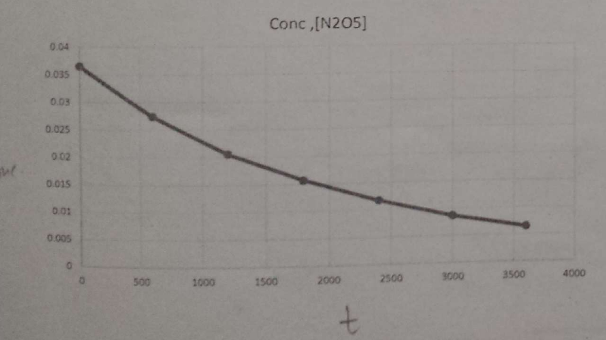
Reactor Theory

1. A chemical batch reactor achieves a reduction of component A from 100 mg/L to 5 mg/L in one hour. If the reaction is known to follow zero order kinetics, determine the rate constant . Repeat the same thing for first order kinetics.
2. Nitrogen pentoxide (N2O5) decomposes to NO2 and O2 at relatively low temperature . Plot a graph of the concentration versus t, ln concentration versus t, and then determine the rate law(order of reaction) and calculate the rate constant

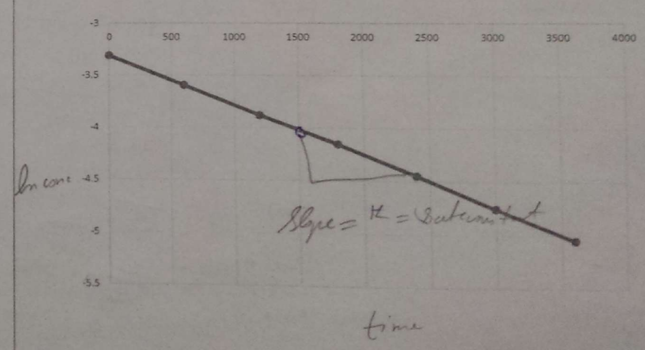
$N_2O_5 \rightarrow NO_2 + O_2$

Time (sec)	Conc ,$[N_2O_5]$,(mg/L)
0	0.0365
600	0.0274
1200	0.0206
1800	0.0157
2400	0.0117
3000	0.00860
3600	0.00640

Numerical 2 :Zero Oder



Numerical 2 :First order



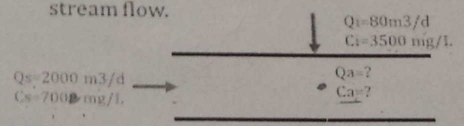
3. Considering the first order kinetics with K value of 0.23 per day and the detention time of 5 days , find out the efficiencies achieved in plug flow and completely stirred tank reactor.

RE = 55% } CSTR
V , Q

For PFR , R.E in terms of VQ

Numerical 4

- A stream carries a flow of 2000 m3/day with TDS concentration of 700 mg/l. At a point 80 m3/d of industrial wastewater with a TDS concentration of 3500mg/l is being added to the stream. Find out the resulting TDS concentration in the stream soon after the industrial waste is completely mixed with the stream flow.



$Q_a = 2000 + 80 = 2080 \text{ m}^3/\text{d}$

$Q_s C_s + Q_i C_i = Q_a C_a$

$(2000)(700) + (800)(3500) = (2080) C_a$

$C_a = 2019 \text{ mg/L}$

Reactor Theory

5. A CSTR with a volume of 800 m3 is treating 4000 m3/day of water having a pollutant concentration of 10 mg/L. If the first order rate coefficient for the pollutant is 0.8 per hour, calculate the removal efficiency of the pollutant in the reactor. Also determine the concentration in the outflow of the reactor.
6. A PFR with a volume of 800 m3 is treating 4000 m3/day of water having a pollutant concentration of 10 mg/L. If the first order rate coefficient for the pollutant is 0.8 per hour, calculate the removal efficiency of the pollutant in the reactor. Also determine the concentration in the outflow of the reactor

(3) Data:

1st order
$K = 0.23$ per day
$t = 5$ days
$\eta = ?$ i) P.FR
ii) CSTR

i) In P.F.R

$C = C_0 e^{-Kt}$

$\frac{C}{C_0} = e^{-Kt}$

$\eta = \left(\frac{C}{C_0}\right) \times 100$

$= e^{-0.23 \times 5} \times 100$

$= 31.66\%$

ii) CSTR

$C = \frac{C_0}{1+Kt}$

$\frac{C}{C_0} = \frac{1}{1+Kt}$

$\eta = \left(\frac{C}{C_0}\right) \times 100$

$= \frac{1}{1+0.23 \times 5} \times 100$

$= 46.51\%$

(5) Data:

CSTR

$V = 800 m^3$
$Q = 4000 m^3/d$
$C_0 = 10 mg/L$

$Q = \frac{V}{t}$

$t = \frac{V}{Q} = \frac{800}{4000}$

$t = 0.2$ day
$= 4.8$ hrs

First order rate of conc. $= 0.8$ per hour
i) Removal efficiency $= (\eta_R) = ?$
ii) Conc. in out flow $C = ?$

Sol:

i) $C = \frac{C_0}{1+Kt}$

$= \frac{10}{1+0.8 \times 4.8}$

$= 2.066$

$R.E = \left(1 - \frac{C}{C_0}\right) \times 100$

$= \left(1 - \frac{2.066}{10}\right) \times 100$

$= 79.34\%$

OR

$\eta = \frac{C}{C_0} = \frac{1}{1+Kt} \times 100$

$= \frac{1}{1+0.8 \times 4.8} \times 100$

$\eta = 20.66\%$

$R.E = 100 - 20.66$
$= 79.34\%$

ii) $\eta = \frac{C}{C_0} \times 100$

$20.66 = \frac{C}{10} \times 100$

$C = 2.066$

(6) Data:

PFR

$V = 800 m^3$
$Q = 4000 m^3/d$
$C_0 = 10 mg/L$
$t = 4.8$ hrs

First order $K = 0.8$ per hr
i) Removal eff = ?
ii) Conc. in outflow = ?

Sol.

$C = C_0 e^{-Kt}$

$= 10 \times e^{-0.8 \times 4.8}$

$= 0.215 mg/L$

$\eta = \frac{C}{C_0} = e^{-Kt} \times 100$

$= e^{-0.8 \times 4.8} \times 100$

$= 2.15\%$

$\eta_R = 100 - 2.15$

$= 97.85\%$