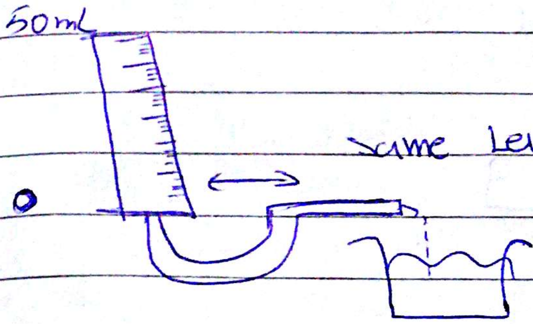
Experiment 5 : Development of kinetic Rate Equation from Hydraulic Analog methods

* objectives:
1) develop kinetic rat equation of (in batch reactor)
A) ~~order~~ different types
B) different order.

CASE 1 : first order irreversible reaction.



same level (zero) [Horizontal ~~capil~~ capillary]

$-r_A = k \cdot C_A^n$ $\boxed{n=1}$

$-r_A = \frac{dC_A}{dt}$ assuming volum ≡ Concentratio

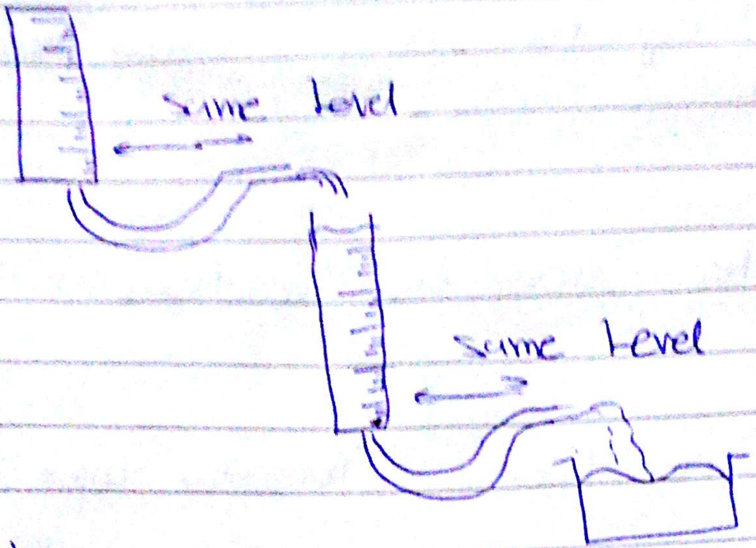
$\frac{dC_A}{dt} = \frac{\Delta C_A}{\Delta t} = \frac{(50\ mL - 0\ mL)}{time}$

$\frac{dC_A}{dt} = k \cdot C_A^n$ → Linearization

$\ln\left(\frac{dC_A}{dt}\right) = \ln(k) + n \ln(C_A)$ ← plot

slope = ~~slope~~ (n) = 1
intercept = ln(k) ← find (k)

Case 2: first order series reaction



$A \xrightarrow{k_1} R \xrightarrow{k_2} S$ (Rxn)

$-r_A = k_1 C_A^m$ $m = n = 1$
$r_S = k_2 C_R^n$

SAME approach as Part (1)

$$\ln\left(\frac{dC_a}{dt}\right) = \ln k_1 + m \ln(C_a)$$

$$\ln\left(\frac{dC_r}{dt}\right) = \ln(k_2) + n \ln(C_r)$$

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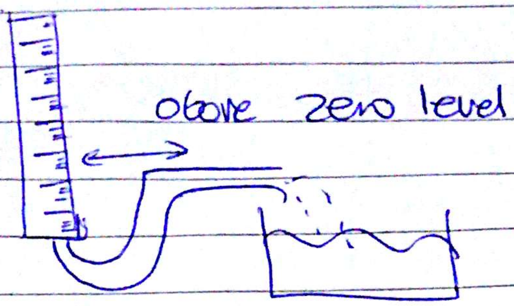
Case 3 first order reversible reaction



$$A \leftrightarrow R$$

$-r_A = k_1 C_A - k_2 C_R$

linear form: $\ln\left(\dfrac{C_0 - C_r}{C_a - C_r}\right) = k_1 t + I$

k_c: equilibrium const

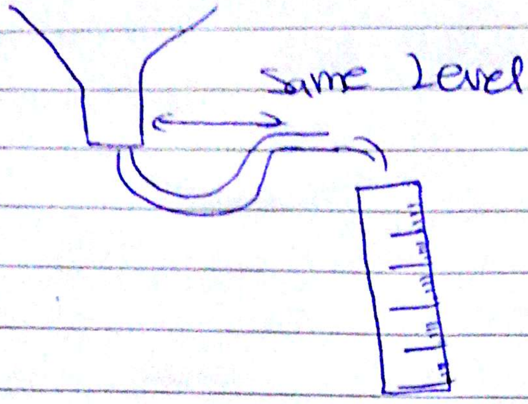
k_1: slope

$$\left(k_2 = \frac{k_1}{k_c}\right)$$

→ Simple + inexpensive experiment method to determine kinetic rate equation

Case 4: Reaction with order not equal to (1) [non-Linear eq. reactions]

PART A $\boxed{n < 1}$



$-r_A = k C_A^n$ $\boxed{n<1}$

linear form:

$$\ln C_a = (n-1)\ln(t_{1/2}) + \ln\frac{(2^{n-1}-1)}{k(n-1)}$$

slope $= (n-1)$

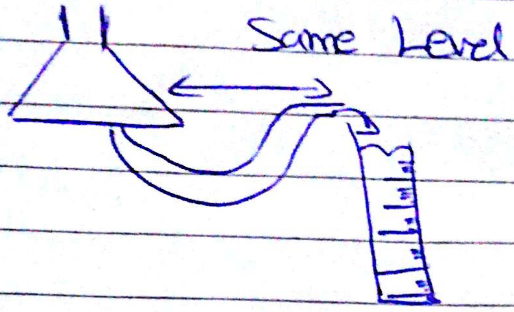
intercept $= \ln\left[\frac{2^{n-1}-1}{k(n-1)}\right]$ assume $t = (t_{1/2})$

Part B ~~~ $n > 1$

use

$$k = \frac{(2^{n-1}) - 1}{\exp(i)\,(n-1)}$$

PART B



rate: $-r_A = kC_A^n \qquad n > 1$

Linear form

$$\ln(C_a) = (n-1) * \ln(t_{1/2}) + \ln\left(\frac{2^{n-1} - 1}{k\,(n-1)}\right)$$

$$k = \frac{(2^{n-1}) - 1}{\exp(I)\,(n-1)}$$

$K_c = \frac{k_1}{k_2} \Rightarrow$ find k_2 $\qquad K_c$: equilibrium