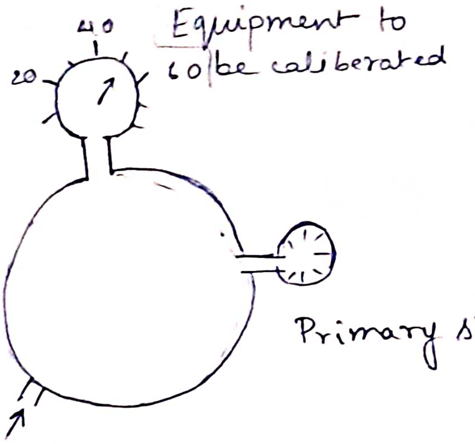
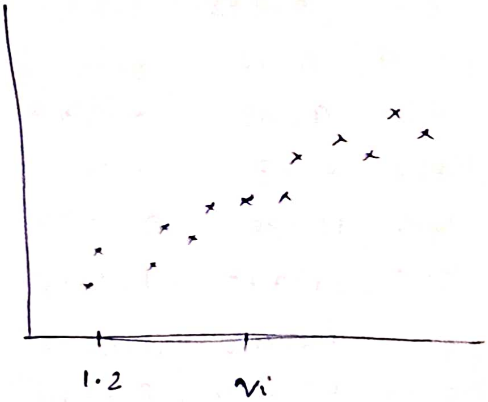




$\hat{q}_0 = m q_i + b$

$L = \Sigma (q_0 - \hat{q}_0)^2$

$\frac{dL}{dm} = 0 , \quad \frac{dL}{db} = 0$

$$m = \frac{N \Sigma q_i q_0 - \Sigma q_i \Sigma q_0}{\left[N \Sigma q_i^2 - (\Sigma q_i)^2\right]}$$

$$b = \frac{\Sigma q_0 \Sigma q_i^2 - (\Sigma q_i q_0)(\Sigma q_i)}{\left[N \Sigma q_i^2 - (\Sigma q_i)^2\right]}$$

N = Total no. of data points.

Random var — you can specify its prob distribuⁿ not the value

$1\Sigma, 2\Sigma$? ±? 99% → 3Σ ??

$m = \mu = 12.3$, $S = 0.05 = S_m$
↳ s is ~~un~~known,

$m = 12.3 \pm 0.15$

$$S_m^2 = \frac{N (S_{q_0})^2}{N \Sigma q_i^2 - (\Sigma q_i)^2}$$

fⁿ of random variable (x) → $Y = X + C$

$E(Y) = E(X) + E(C)$

$V(Y) = V(X) + V(C)$

$$S_b^2 = \frac{(S_{q_0})^2 \Sigma q_i}{N \Sigma q_i - (\Sigma q_i)^2}$$

$$S_{q_0}^2 = \frac{1}{N-2} \Sigma \left[(m q_i + b) - q_0\right]^2$$

obs	q_i	q_o	$q_i q_o$	q_i^2	Res
1	0.19	3.8	0.722	0.0361	-0.90
2	0.40	10.4	4.16	0.16	1.85
3	0.63	15.1	9.513	0.3969	2.34
4	0.60	9.3	5.58	0.36	
5	0.78	14.6	11.388	0.6084	
6	1.05	20.9	21.945	1.1025	
7	1.74	31.3	54.462	3.0276	
8	1.62	32.7	52.974	2.6244	
N=8	6.23	138.1	160.744	8.3159	

$m = -162.086327$

$b = \frac{146.99067}{-2.6269} = -55.955$

$Res = [(mq_i + b) - q_o]$

$\hat{q}_o = m q_i' + b$

$m = 18.28$, $S_m =$

$b = 1.24$, $S_b =$

$S_m^2 = \dfrac{N (S q_o)^2}{N \Sigma q_i^2 - (\Sigma q_i)^2}$

$S_b^2 = \dfrac{(S q_o)^2 \, \Sigma q_i}{N \Sigma q_i - (\Sigma q_i)^2}$

$S_m = 1.4034$

$S_b = 1.3137$

$S_{q_o}^2 = \dfrac{1}{N-2} \Sigma[(m q_i + b) - q_o]^2 = 4.2543$

$N = 8$

$\Rightarrow S_{q_o} = 2.0626$

$m = 18.28 \pm 3 (S_m)$ $= \cancel{18}\ 18.28 \pm 4.2$

$b = 1.24 \pm 3 (S_b)$ $= 1.24 \pm 3.9$

$\rightarrow S_q = 24.61$, $q_i = 1.2781$

$S_{q_i}^2 = \dfrac{S_{q_o}^2}{m^2} = 0.0127$

$S_{q_i} = 0.1128$

$\therefore q_i = 1.2781 \pm 3 (S_{q_i})$

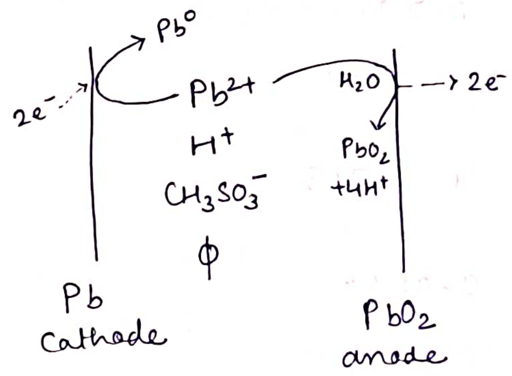
$= 1.2781 \pm 0.339$

DAE

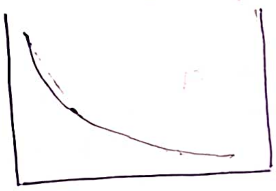
Flux = velocity × Density

flux → $\frac{\text{flow rate}}{\text{area}}$

Lead-acid battery :



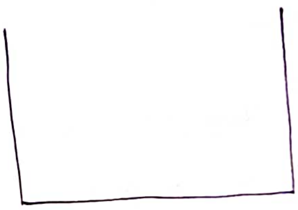
Pb^+



$$Pb^{2+} \cancel{+2e^-} \xrightarrow{+2e^-} Pb$$

$$H_2O + Pb^{2+} \xrightarrow{-2e^-} PbO_2 + 4H^+$$

H^+



$CH_3SO_3^-$

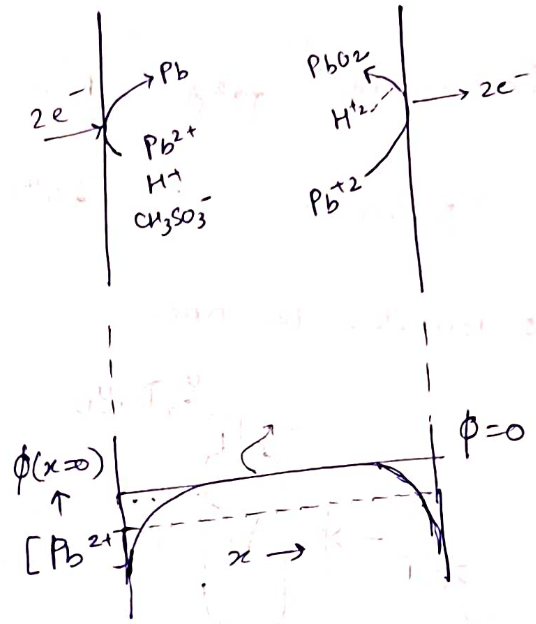
t

ϕ

Drop.

Develop Model Equations

c_i, ϕ



- ions will accelerate towards the electrode.
till they ~~reach~~ achieve terminal velocity.
they stop becz of drag force.
- due to presence of other ions
- due to viscosity of ~~the~~ medium

• Chemical potential | Electrical potential

— 2 fluxes

Diffusive flux ⟶ $N = -D \frac{dc}{dx}$

Migration flux

unit charge : $-\frac{\partial \phi}{\partial x}$

$-z_i e \frac{\partial \phi}{\partial x}$:= force due to electric potential.

valency of i^{th} ion; charge on 1 ion.

(Drag force): ~~6πRsuμ~~

$$6\pi R_s u \mu = -z_i e \frac{\partial \phi}{\partial x}$$

flux : vel. x density.

$$\boxed{\frac{\partial c_i}{\partial t} = -\frac{\partial N_i}{\partial x}} \rightarrow \text{Fick's } 2^{nd} \text{ Law}$$

N_i = net flux : migration flux, diffusive flux

c_i = conc. of i^{th} ion.

$$N_i = -D_i \frac{\partial c_i}{\partial x} + (\quad)$$

$$D_i = \frac{RT}{6\pi \mu R_s}$$

$$-z_i e \frac{\partial \phi}{\partial x} = \frac{RT}{D_i} \cdot u$$

$$\therefore u = \frac{-z_i e D_i}{RT} \frac{\partial \phi}{\partial x}$$

Migration flux = $\frac{-z_i D_i F}{RT} \frac{\partial \phi}{\partial x} c_i (N_A)$

↳ molar conc

$\frac{n}{V} = \frac{N}{N_A}$

$$\frac{\partial c_i}{\partial t} = -\frac{\partial}{\partial x}\left[-D_i \frac{\partial c_i}{\partial x} - \frac{z_i c_i D_i F}{RT} \frac{\partial \phi}{\partial x}\right]$$

4 unk. : ϕ

3 eqn :

Electroneutrality condⁿ: $\sum z_i c_i = 0$

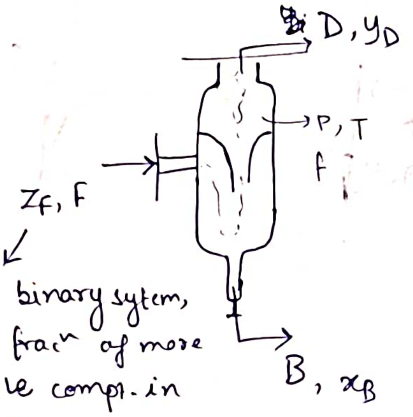
Poissons eqⁿ: $\nabla^2 \phi = -\frac{F}{\epsilon} \sum z_i c_i$

10^{16} (v. large)

$\boxed{\sum z_i c_i \simeq 0}$

Q) Formulate the DAE.

$f \rightarrow$ fracⁿ of feed vapourised.



For a binary system, mole fracⁿ of more volatile compo. in the feed.

Assumption: F ✓

Rel volatility is const. k

Unk: x_B, y_D, D, B.

given: f, F, z_f, k

$F = D + B$

$F = (f+1)B$

$F z_f = D y_D + B x_B \rightarrow$

$f = \frac{D}{F}$ ✓

$$\boxed{z_f = f y_D + (1-f) x_B} \quad (1)$$

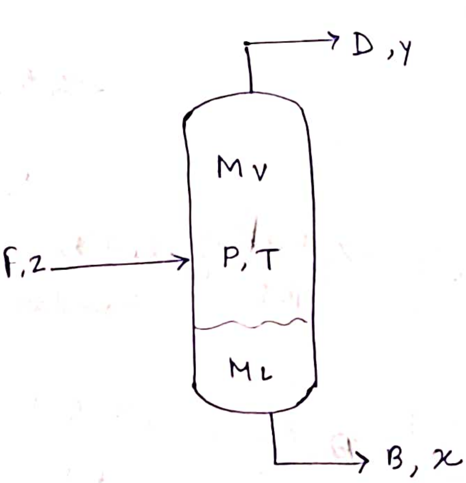
$\frac{y_D}{x_B} = k$

y_D ~~$= k_i x_B$~~

$$\boxed{y_D = \frac{\alpha x_B}{1 + (\alpha - 1) x_B}} \quad (2)$$

4 Write model on transient

Write the transient:



$M = M_V + M_L$

$\frac{d}{dt}(M_V + M_L) = F - D - B$

$\frac{dM_i}{dt} = F z_i - D y_i - B x_i$

(H.W) complete

Transient Mass balance for this flash vessel & formulate the closed set of D.A.E for this case.

$$D_1 \frac{dc_1}{dx} + \frac{\cancel{\sigma}\, z_1 c_1 D_1 F}{RT} \frac{d\phi}{dx} = k_1$$

$$D_2 \frac{dc_2}{dx} + \frac{z_2 c_2 D_2 F}{RT} \frac{d\phi}{dx} = k_2$$

$$D_3 \frac{dc_3}{dx} + \frac{z_3 c_3 D_3 F}{RT} \frac{d\phi}{dx} = k_3$$

$$z_1 c_1 + z_2 c_2 + z_3 c_3 = 0$$

general ~~set~~ form of set of ODES:

$$\frac{dx_1}{dt} = f_1(x_1, x_2, x_3, t)$$

$$\frac{dx_2}{dt} = f_2(x_1, x_2, x_3, t)$$

$$\cancel{\frac{dx_3}{dt}} 0 = f_3(x_1, x_2, x_3, t)$$

$$\cancel{\frac{dx_3}{dt} = f_4(x_1, x_2, x_3, t)}$$

Stiff → Rising sharply.