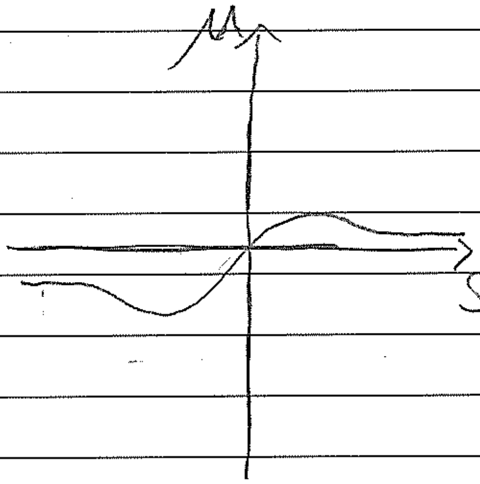
Goh Keng Siang

1 a) $\mu = AS/(B+S+CS^2)$ $\quad A, B > 0$, $C \geq 0$

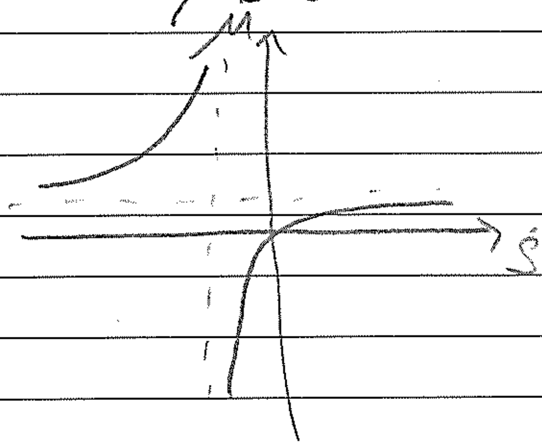
i) $C > 0$

$$\mu = \frac{AS}{B+S+CS^2}$$



ii) $C = 0$

$$\mu = \frac{AS}{B+S}$$



$$\frac{d\mu}{dS} = \frac{A(B+S+CS^2) - (1+2CS)(AS)}{B+S+CS^2}$$

$$= \frac{AB + AS + ACS^2 - AS - 2ACS^2}{B+S+CS^2}$$

$$= \frac{A(B-CS^2)}{B+S+CS^2}$$

$$\frac{d\mu}{dS} = \frac{A(B+S) - AS}{B+S}$$

$$= \frac{AB + AS - AS}{B+S}$$

$$= \frac{AB}{B+S}$$

bi) $$C_{(x,t)} = \frac{M}{\sqrt{4\pi Dt}} e\left(-\frac{(x-ut)^2}{4Dt}\right).$$

$t = 90 \times 60$

$x = 0$ (max)

$$C_{(x,t)} = \frac{10^{-5}/\pi(1\times10^{-3})^2}{\sqrt{4\pi(10^{-4}\times10^{-4})\times 90\times60}} e\left(\frac{-(0-0)^2}{\text{~~~}}\right)$$

$= 122.19\,g/m^3$

ii) $95\% = 4\sigma$

$= 4\sqrt{2Dt}$

$= 0.04157\,m$

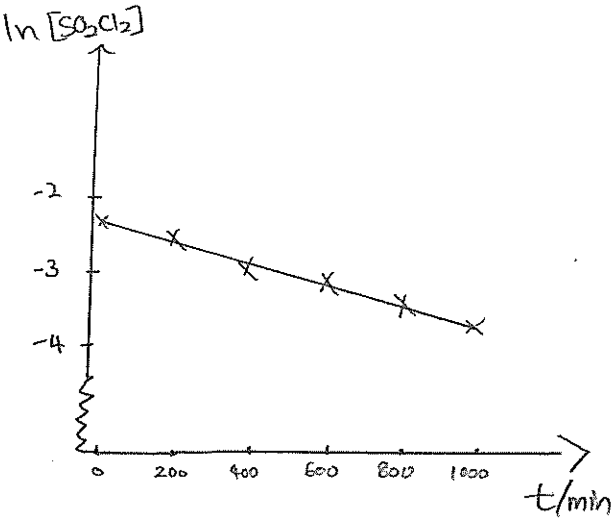
1bi) $\frac{M}{\sqrt{4\pi D t}} e^{\left(\frac{-(x-ut)^2}{4Dt}\right)}$

for cloud length is determined by D & t, the increase in C does not affect it.

2a)

$SO_2Cl_2 \rightarrow SO_2 + Cl_2$.

t	$[SO_2Cl_2]$	$\ln[SO_2Cl_2]$
0	0.1	-2.303
200	0.0768	-2.567
400	0.0590	-2.83
600	0.0453	-3.09
800	0.0348	-3.358
1000	0.0267	-3.623



first order : $C = C_0 e^{kt}$

$\ln C = \ln C + kt$

gradient.

$\therefore k = \frac{-2.303 - (-3.623)}{0 - 1000}$

$= -0.00132 \text{ min}^{-1}$ //

ii)

$[SO_2Cl_2] = 0.005$ mol/L.

$\ln(0.005) = \ln(0.1) - 0.00132(t)$

$t = 2269.5$ min //

2bi) time taken to reach 10m downstream,

$10/(10^{-9}/\pi(1\times10^{-3})^2)$

$= 131416s$

$= 523.6min$

Amt of SO_2Cl_2 = ~~$\frac{13.5}{32+16\times2+71}$~~

$= 0.1 mol/L.$

$C = 0.1e^{-0.00132(523.6)}$

$= 0.0501$ mol/L.

since $SO_2Cl_2 : Cl_2$
1 : 1

whatever that is reacted becomes Cl_2.

$\therefore 0.1 - 0.0501$

$= 0.05 mol/L$ Cl_2 //.

ii) if longitudinal dispersion is taken into account, concentration of Cl_2 computed in (bi) will decrease. Cl_2 at that particular point will diffuse outwards to less concentrated area. Bigger plume ~~to~~ M (higher)

$\therefore$ lower concentration //

3a) $t = \frac{60\times10^3}{10}$

$= 6000mins$

Pulse input w̄ rxn. (PFR)

$C_E = C_P e^{-kt}$

$= 10e^{-0.0002\times6000}$

$= 3.012 mg/L$

b) This is a case of a CMFR & PFR

$C_E = C_I e^{-(tk)}$ — C_x

$1 = C_I e^{-(0.0002)(6000)}$

$C_I = 3.32 mg/L$.

$C_I = C_x$.

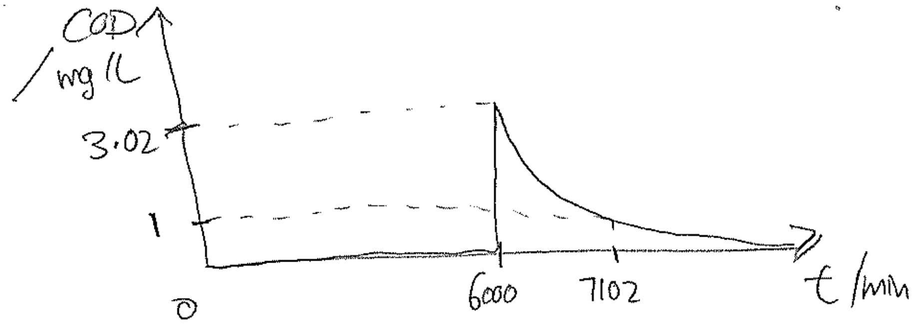
$3.32 = C_o e^{-(\frac{Q}{V}+k)t}$.

$3.32 = 10e^{-(\frac{40}{50000}+0.0002)t}$

$t = 1102.58 + 6000$

$= 7102$ min //

3c)



4ai).

$$C_G = H_{cc} C_w$$

$$0.00316 = H_{cc}\ 9.97\times10^{-3}$$

$$H_{cc} = 0.317$$

$PV = nRT$

$$\frac{n}{V} = \frac{P}{RT} = \frac{0.076}{0.082\times(20+273)} = 0.00316\ \text{mol/L}$$

ii)

$$K_d = f_{oc} K_{oc} = \frac{5}{100} \times 0.63\,(10^{2.33}) = 6.735\ \text{L/Kg} = 6.735\times10^{-6}\ \text{m}^3/\text{g}$$

$$K_p = \rho_s K_d = 1.5\times10^{3} \times 6.735\times10^{-6}\times10^{3} = 10.10$$

iii)

$$\frac{1}{F_{solid}} = 1 + \frac{V_w}{V_s}\frac{1}{K_p} + \frac{V_g}{V_s}\frac{H_{cc}}{K_p}$$

$$\frac{1}{F_s} = 1 + \frac{10}{1}\left(\frac{1}{10.10}\right) + \frac{100}{1}\left(\frac{0.317}{10.10}\right)$$

$$F_s = 0.195$$

$$\frac{1}{F_g} = \frac{V_s}{V_g}\frac{K_p}{H_{cc}} + \frac{V_w}{V_g}\frac{1}{H_{cc}} + 1$$

$$\frac{1}{F_g} = \frac{1}{100}\left(\frac{10.10}{0.317}\right) + \frac{10}{100}\left(\frac{1}{0.317}\right) + 1$$

$$F_g = 0.612$$

$$\frac{1}{F_w} = \frac{V_s K_p}{V_w} + 1 + \frac{V_g H_{cc}}{V_w}$$

$$\frac{1}{F_w} = \frac{1\times10.10}{10} + 1 + \frac{100\times0.317}{10}$$

$$F_w = 0.193$$

$$F_s + F_g + F_w = 1$$

Assume mass of TCE remains constant, no degradation/rxn.

5ai) $S = 0.4 / 0.25$

$= 1.6 \ s^{-1}$

$k_L a = \frac{(DV)^{1/2}}{H^{3/2}}$

$= \frac{(4.3\times10^{-10} \times 0.4)^{1/2}}{(0.25)^{3/2}}$

$= 1.049\times10^{-4} \ s^{-1}$ //

ii) $1 = 20 e^{-(1.049\times10^{-4} + 1\times10^{-4})t}$

$t = 14620 \ s$

$x = 0.4 \times 14620$

$= 5848 m$ //