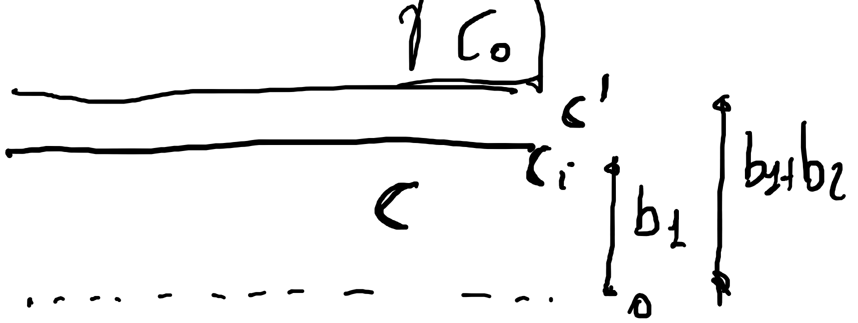


$$Hb + O_2 \rightleftarrows HbO_2$$

$$\frac{\partial c'}{\partial t} = D_1 \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$\text{(3)} \quad \frac{\partial y}{\partial t} = D_{Hb} \frac{\partial^2 y}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$C = \alpha c'$$

$$D_1 \frac{\partial c'}{\partial x} = D_2 \alpha \frac{\partial c}{\partial x}$$

$$\frac{\partial c'}{\partial t} = D_1 \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2}$$

$$\frac{\partial y}{\partial t} = D_{Hb} \frac{\partial^2 y}{\partial x^2}$$

$$c = \alpha c'$$

$$D_1 \frac{\partial c'}{\partial x} = \alpha D_1 \frac{\partial c}{\partial x}$$

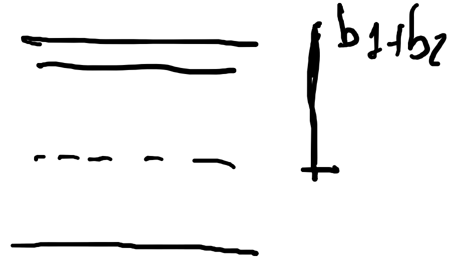
Cond. stazionarietà dell'CO_2 $\quad CO_2$

$$\frac{\partial c'}{\partial t} = \phi = \frac{\partial c}{\partial t} \qquad D_{Hb} \simeq \phi$$

$$\begin{cases} D_1 \dfrac{\partial^2 c'}{\partial x^2} = \phi \\ D_2 \dfrac{\partial^2 c}{\partial x^2} = \phi \\ \dfrac{\partial y}{\partial t} = \phi \end{cases} \qquad 3$$

$$y = y_0 = \text{cost}$$

$$D_1 \frac{\partial^2 c'}{\partial x^2} = \phi \qquad \frac{\partial^2 c'}{\partial x^2} = \phi \qquad \frac{\partial c'}{\partial x} = A$$



$$c'(b_1+b_2) - c'(x) = \underline{A}x + \underline{b}$$

$$c'(b_1+b_2) = C_o$$

$$c'(b_2) = C_i$$

$$c'(b_1+b_2) - c'(b_1+b_2) = A(b_1+b_2) + b$$

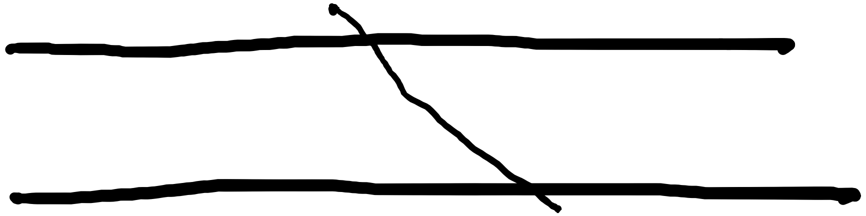
$$C_o - C_o = A(b_1+b_2) + b = \phi$$

$$b = -A(b_1+b_2)$$

$$c'(b_1+b_2) - c'(b_1) = Ab_1 - Ab_1 - Ab_2$$

$$C_o - C_i = -Ab_2 \qquad A = -\frac{C_o - C_i}{b_2} = \frac{C_i - C_o}{b_2}$$

$$c'(x) = c_0 - Ax - b = c_0 - \frac{c_1 - c_0}{b_2}x - \frac{c_1 - c_0}{b_2}(b_1 + b_2)$$



$$D_2 \frac{\partial^2 c}{\partial x^2} = 0 = D_2 \frac{\partial}{\partial x}\left(\frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial x}\left(D_2 \frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial x}\left(\frac{D_1}{\alpha}\frac{\partial c'}{\partial x}\right)$$

$$= \frac{D_1}{\alpha}\frac{\partial^2 c'}{\partial x^2} = \phi$$

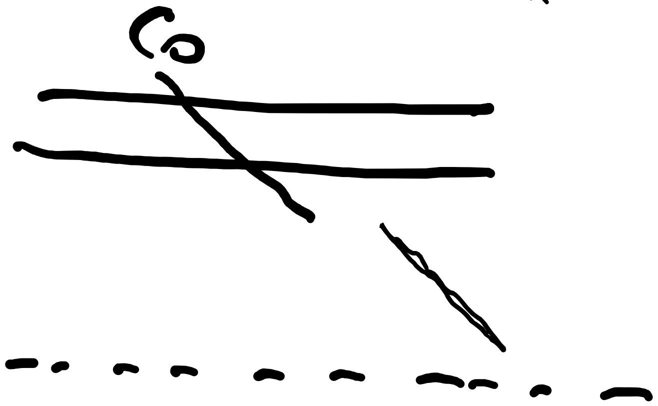
$$\frac{\partial^2 c}{\partial x^2} = 0 \qquad \frac{\partial c}{\partial x} = F \qquad c(x) - \underset{\phi}{\underset{\shortparallel}{c(0)}} = Fx + G.$$

$C(x) = Fx + G$ $\qquad$ $C(0) = F \cdot 0 + G \Rightarrow G = \varnothing$

$C(x) = Fx$ $\qquad$ $C = \alpha C'$

$C(b_1) = c_i$ $\qquad$ $C(b_1) = c_i = F b_1 \Rightarrow F = \frac{c_i}{b_1}$

$C(x) = \frac{c_i}{b_i} x = \frac{c'(b_1)}{\alpha b_1} x$



$$\frac{\partial c'}{\partial t} = D_1 \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2} - Kc$$

$$\frac{\partial y}{\partial t} = D_{Hb} \frac{\partial^2 y}{\partial x^2}$$

$$\frac{\partial c'}{\partial t} = \frac{\partial c}{\partial t} = 0 \qquad D_{Hb} \simeq \phi$$

$$\begin{cases} D_1 \dfrac{\partial^2 c'}{\partial x^2} = \phi \\ D_2 \dfrac{\partial^2 c}{\partial x^2} = Kc \quad (2) \\ \dfrac{\partial y}{\partial t} = \phi \end{cases}$$

$$\frac{\partial^2 C}{\partial x^2} = \frac{K''}{D_2} C \qquad \Gamma$$

$$\ddot{C} - \Gamma C = \phi$$

$$\lambda^2 - \Gamma = \phi \qquad \lambda^2 = \Gamma \Rightarrow \lambda = \pm\sqrt{\Gamma} \quad \lambda_1 = +\sqrt{\Gamma}, \quad \lambda_2 = -\sqrt{\Gamma}$$

$$C = A e^{-\lambda_1 x} + B e^{-\lambda_2 x}$$

$$C(0) = 0 = A + B = \phi \Rightarrow A = -B$$

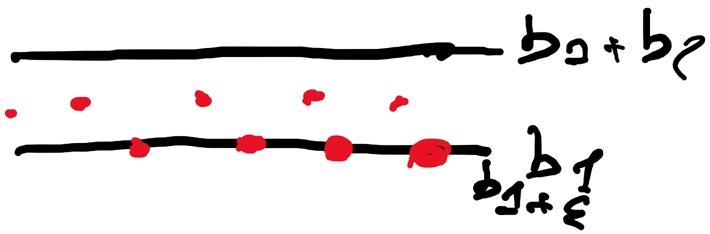
$$C = A \left[e^{-\lambda_1 x} - e^{-\lambda_2 x} \right] \qquad C(b_1) = C_i$$

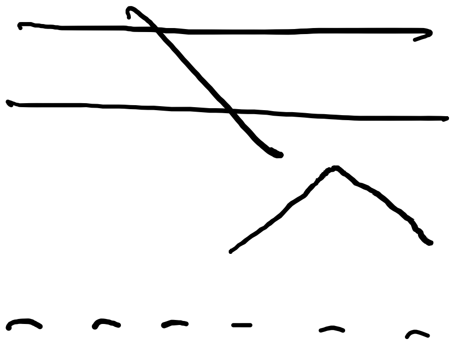
$$C(b_1) = C_i = A\left[e^{-\lambda_1 b_1} - e^{-\lambda_2 b_1}\right] \Rightarrow A = \frac{C_i}{e^{\lambda_1 b_1} - e^{\lambda_2 b_1}}$$

$$C(x) = \frac{C_i}{e^{\lambda_1 b_1} - e^{\lambda_2 b_1}}\left[\underbrace{e^{\lambda_1 x}}_{\mathrm{I}} - \underbrace{e^{\lambda_2 x}}_{\mathrm{II}}\right]$$

I = Reazione con acqua

II = Reazione di scissione.





$$\frac{\partial c'}{\partial t} = D_1 \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$\frac{\partial y}{\partial t} = D_{flb} \frac{\partial^2 y}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$\frac{\partial c}{\partial t} = \phi = \frac{\partial c'}{\partial t} \qquad D_{flb} \simeq 0$$

$K' = \phi$ $\qquad C_0$

$$\frac{\partial c'}{\partial t} = D_f \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2} - Kcy$$

$$\frac{\partial y}{\partial t} = -Kcy + D_{flb} \frac{\partial^2 y}{\partial x^2}$$

CO

$$\begin{cases} D_1 \dfrac{\partial^2 c'}{\partial x^2} = \phi & (1) \\ D_2 \dfrac{\partial^2 c}{\partial x^2} = Kcy & (2) \\ \dfrac{\partial y}{\partial t} = -Kcy & (3) \end{cases}$$

$$c = \alpha c'$$

$$D_{2} \frac{\partial c}{\partial x} = \alpha D_1 \frac{\partial c'}{\partial x}$$

$$\frac{\partial^2 c'}{\partial x^2} = \phi \qquad \frac{\partial c'}{\partial x} = A$$

$$c'(b_1+b_2) - c'(x) = Ax + B$$

$$c_0 = c'(b_1+b_2) \qquad c'(b_1) = c_i$$

$$c'(b_1+b_2) - c'(b_1+b_2) = A(b_1+b_2) + B$$

$$A(b_1+b_2) + B = \phi$$

$$B = -A(b_1+b_2)$$

$$c'(b_1+b_2) - c'(b_1) = Ab_1 - Ab_1 - Ab_2$$

$$C_o - C_i = -Ab_2 \qquad A = -\frac{c_o - c_i}{b_2} = \frac{c_i - c_o}{b_2}.$$

$$C_o - C'(x) = \frac{C_i - C_o}{b_2}x - \frac{(c_i - c_o)}{b_2}(b_1 + b_2)$$

$$C'(x) = C_o - \frac{C_i - C_o}{b_2}x + \frac{(C_i - C_o)}{b}(b_1 + b_2)$$

$$\frac{\partial y}{\partial t} = -KCy \qquad \frac{\partial y}{y} = -Kc\,dt \qquad c = \alpha c'$$

$$\int_{y_0}^{y(t)} \frac{\partial y}{y} = \int_0^t -K\alpha c'\,dt \qquad \ln y(t)\Big|_{y_0} = -K\alpha c' t$$

$$\boxed{y(t) = y_0\, e^{-K\alpha c' t}}$$

(2)

$$D_2 \frac{\partial^2 c}{\partial x^2} = K c y$$

Somma 2 e 3 equazione

$$D_2 \frac{\partial^2 c}{\partial z^2} + \frac{\partial y}{\partial t} = \phi$$

$$D_2 \frac{\partial^2 c}{\partial x^2} = -\frac{\partial y}{\partial t} = + \underbrace{y_0 K \alpha}_{= \varepsilon} c' e^{-K \alpha c' t}$$

$$D_2 \frac{\partial^2 c}{\partial x^2} = \varepsilon c' e^{-K \alpha c' t}$$

$$D_2 \frac{\partial^2 c}{\partial x^2} = D_2 \frac{\partial}{\partial x}\left(\frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial x} D_2 \frac{\partial c}{\partial x} = \frac{\partial}{\partial x} \alpha D_1 \frac{\partial c'}{\partial x} =$$

$$= \alpha D_1 \frac{\partial^2 c'}{\partial x^2} = \phi$$

$$0 = \varepsilon c' e^{-k\alpha c' t} \qquad \varepsilon \neq 0$$

$$c' = \phi \qquad c' \neq 0$$

$$e^{-k\alpha c' t} = \phi \qquad t \text{ molto grandi}$$

<u>Saturazione</u>

$$\frac{\partial c'}{\partial t} = D_1 \frac{\partial^2 c'}{\partial x^2}$$

$$\frac{\partial c'}{\partial t} = \phi = \frac{\partial c}{\partial t} \quad DHb = 0$$

$$K' \neq 0$$

$$\frac{\partial c}{\partial t} = D_2 \frac{\partial^2 c}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$\frac{\partial y}{\partial t} = D_{Hb} \frac{\partial^2 y}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$C = \alpha c'$$

$$D_1 \frac{\partial c'}{\partial x} = \alpha D_2 \frac{\partial c}{\partial x}$$

$$D_1 \frac{\partial^2 c'}{\partial x^2} = \phi \qquad 1$$

$$D_2 \frac{\partial^2 c}{\partial x^2} = Kcy - K'(y_0 - y)$$

$$\frac{\partial y}{\partial t} = K'(y_0 - y) - Kcy$$

$$c'(x) = Ax + b \qquad\qquad C = \alpha c'$$

$$D_2 \frac{\partial^2 c}{\partial x^2} + \frac{\partial y}{\partial t} = \emptyset$$

$$D_2 \frac{\partial^2 c}{\partial x^2} = D_2 \frac{\partial}{\partial x}\left(\frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial x} D_2 \frac{\partial c}{\partial x} = \frac{\partial}{\partial x} \alpha \frac{D_1}{\alpha} \frac{\partial c'}{\partial x} =$$

$$= \frac{D_1}{\alpha} \frac{\partial^2 c'}{\partial x^2} = \emptyset$$

$$\frac{\partial y}{\partial t} = \emptyset \qquad \underline{y = \text{cost}.} \qquad \alpha D_1 \frac{\partial c'}{\partial x} = D_2 \frac{\partial c}{\partial x} = D_1 A \alpha$$

$$D_2 \frac{\partial c}{\partial x} = D_1 A \alpha$$

$$\frac{\partial c}{\partial x} = \frac{D_1}{D_2} A \alpha \qquad c(b_1) - c(x) = \frac{D_1}{D_2} A \alpha \, (b_1 - x)$$

$$C(x) = C_i - \frac{D_1}{D_2} A \alpha (b_1 - x)$$

$$\frac{\partial c'}{\partial t} = D_2 \frac{\partial^2 c'}{\partial x^2}$$ (1)

Sistema non è stazionario

$D_{Hb} = \phi \quad K' = \phi$

$$\frac{\partial c}{\partial t} = D_1 \frac{\partial^2 c}{\partial x^2} + K'(y_0 - y) - Kcy$$

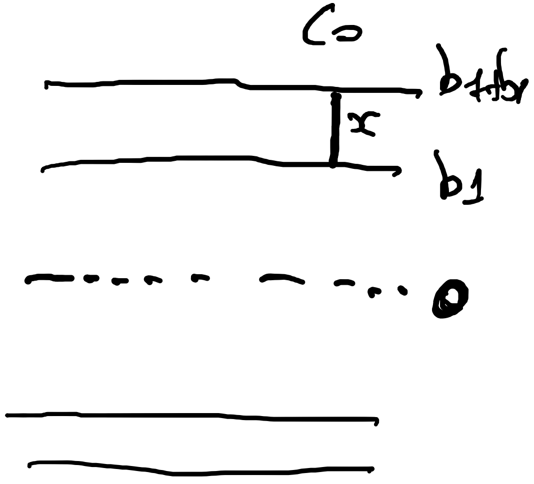
$$\frac{\partial y}{\partial t} = D_{Hb} \frac{\partial^2 y}{\partial x^2} + K'(y_0 - y) - Kcy$$

$$c = \alpha c'$$

$$D_1 \frac{\partial c'}{\partial x} = \alpha D_2 \frac{\partial c}{\partial x}$$

$$\begin{cases} \dfrac{\partial c'}{\partial t} = D_1 \dfrac{\partial^2 c'}{\partial x^2} & (1) \\[2ex] \dfrac{\partial c}{\partial t} = D_2 \dfrac{\partial^2 c}{\partial x^2} - Kcy \\[2ex] \dfrac{\partial y}{\partial t} = -Kcy & (3) \\[2ex] c = \alpha c' \\[2ex] D_1 \dfrac{\partial c'}{\partial x} = \alpha D_2 \dfrac{\partial c}{\partial x} \end{cases}$$

$$\begin{cases} \dfrac{\partial c'}{\partial t} = A \\[2ex] D_1 \dfrac{\partial^2 c'}{\partial x^2} = A \end{cases}$$



$$c'(x,t) - c'(x,0) = At$$

$$c'(x,0) = \emptyset \quad \forall\, b_1+b_2 < x < b_1$$

$$c'(x,t) = At$$

$$c'(b_1+b_2, t) = c_0 \quad \forall t$$

$$c_0 = At \Rightarrow A = \frac{c_0}{t}$$

$$D_1 \frac{\partial^2 c'}{\partial x^2} = A \qquad \frac{\partial^2 c'}{\partial x^2} = \frac{A}{D_1}$$

$$\frac{\partial c'}{\partial x'} = \frac{A}{D_1} x + B$$

$$c'(b_1+b_2, t) - c'(x, t) = \frac{A}{D_1}\frac{x^2}{2} + Bx + C \Big|_{x}^{b_1+b_2}$$

$$\parallel$$

$$c_0 - c'(x,t) = \frac{c_0 x^2}{D_1 t \cdot 2} + Bx + C \Big|_{x}^{b_1+b_2}$$

$$c_0 - c'(x,t) = \frac{c_0}{2D_1 t}\left[(b_1+b_2)^2 - x^2\right] + B(b_1+b_2-x) \qquad c'(b_1+b_2, t) = c_0$$

$$c'(x,t) = -\frac{c_0}{2D_1 t}\left[(b_1+b_2)^2 - x^2\right] - B(b_1+b_2-x) + c_0$$

$$c'(x,t) = \alpha x^2 + \beta x + \gamma$$

$$D_1 \frac{\partial c'}{\partial x} = \alpha D_2 \frac{\partial c}{\partial x}.$$

$$(2\alpha x + \beta) D_1 = \alpha D_2 \frac{\partial c}{\partial x}.$$

$$c(x,t) - \underset{\overset{\shortparallel}{\phi}}{c(0,t)} = \left. 2\alpha \frac{x^2}{2D_1} + \beta \underline{D_1} x + \Gamma \right|_x^{\phi}$$

$$\underline{c(x,t)} = 2\alpha \frac{x^2}{2D_1} + \beta D_1 x$$

$$\frac{\partial y}{\partial t} = -Kcy$$

Δt = piccoli

$$\frac{\partial y}{y} = Kc\,dt$$

$$\ln \frac{y(x,t)}{y(0,0)} = -Kct$$

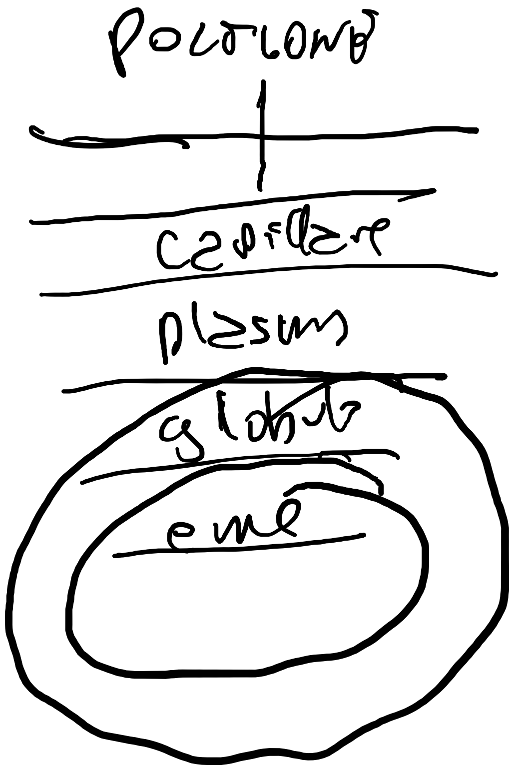
$$y(x,t) = y_0 e^{-Kct}$$

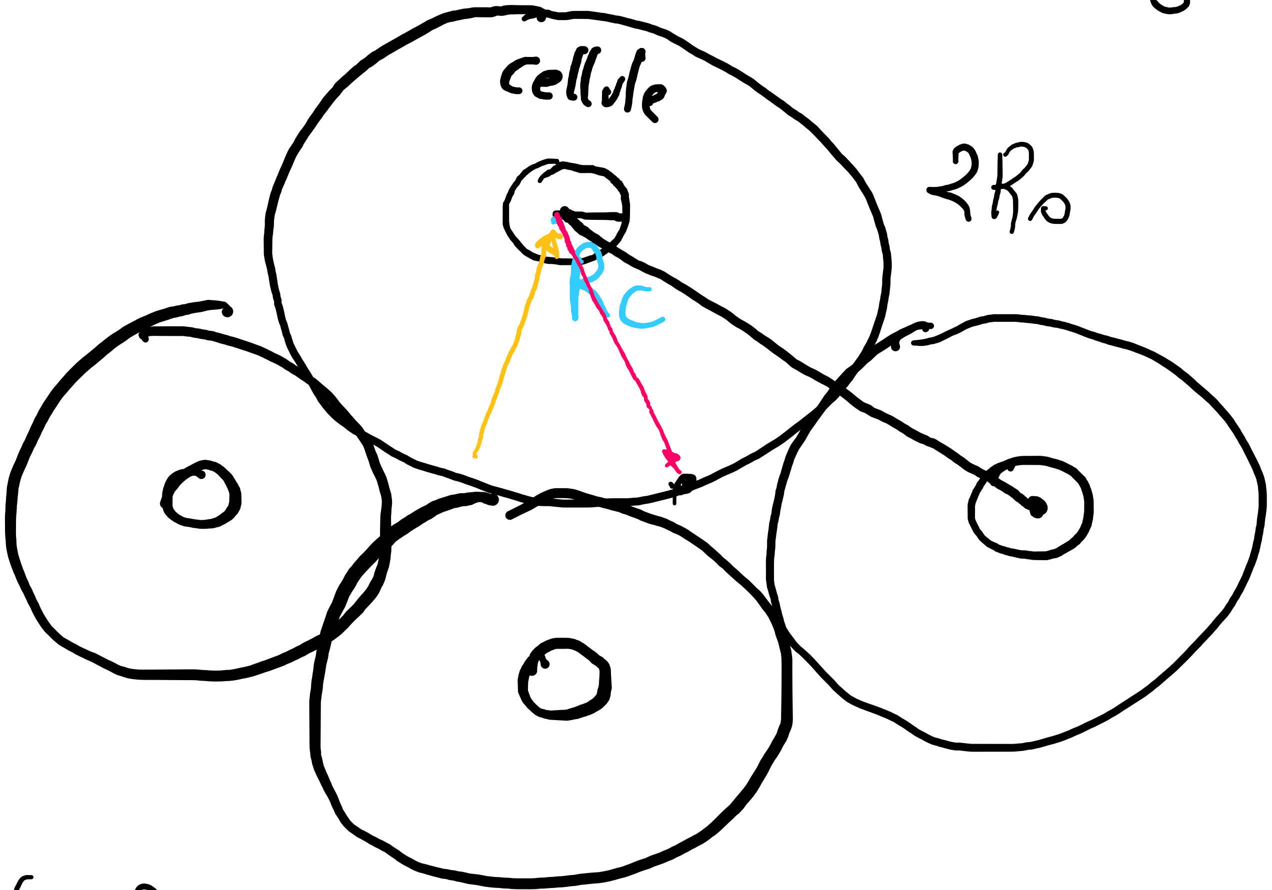
$$\frac{y_0}{2} = y_0 e^{-Kct^*}$$

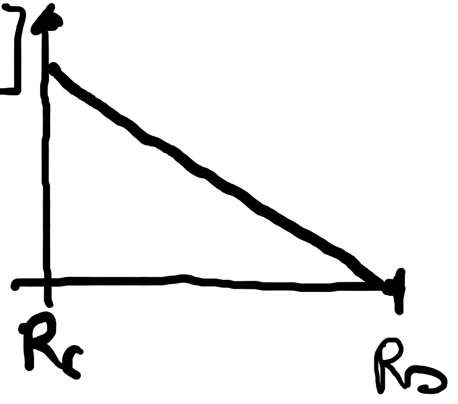
$$y(x,t^*) = \frac{y_0}{2}$$

$$C = HP$$

Modello di Krogh







$$\frac{D_{O_2}}{z}\frac{\partial}{\partial z}\left(z\frac{\partial c}{\partial z}\right) = \text{Cons}\,O_2 = \left[\frac{mol}{cm^3 \cdot s}\right]$$

$$\frac{D_{O_2}}{r}\frac{\partial}{\partial r}\left(r\frac{\partial C}{\partial r}\right) = Cons_{O_2}.$$

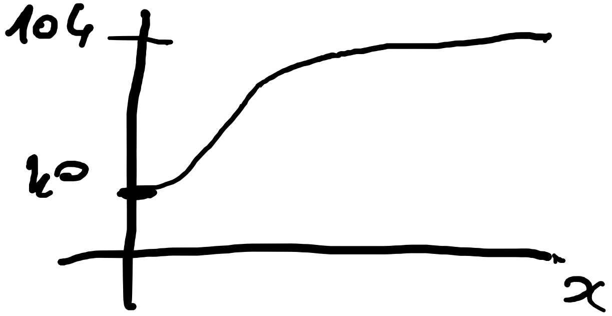
$$C(r) = \frac{Cons_{O_2}}{D_{O_2}}\cdot\frac{r^2}{2} + B\ln r + C$$

$$\frac{\partial}{\partial r}\left(r\frac{\partial C}{\partial r}\right) = \frac{Cons_{O_2}}{D_{O_2}}\cdot r$$

$$R_0 = 50\,\mu m$$

$$C(R_c) = C_0 = H P_0$$

$$r\frac{\partial C}{\partial r} = \frac{Cons_{O_2}}{D_{O_2}}\cdot\frac{r^2}{2} + B$$



$$\frac{\partial C}{\partial r} = \frac{Cons_{O_2}}{D_{O_2}}\cdot\frac{r}{2} + \frac{B}{r}.$$

$$C(R_0) = \emptyset$$

$$-\frac{D_{CO_2}}{r}\frac{\partial}{\partial r}\left(r\frac{\partial c}{\partial r}\right)=2d \cdot CO_2$$

$$\frac{\partial}{\partial r}\left(r\frac{\partial c}{\partial r}\right)=-\frac{2d\,CO_2}{D_{CO_2}}\,r$$

$$r\frac{\partial c}{\partial r}=-\frac{2d\,CO_2}{D_{CO_2}}\frac{r^2}{2}+B$$

$$\frac{\partial c}{\partial r}=-\frac{2d\,CO_2}{D_{CO_2}}\frac{r}{2}+\frac{B}{r}$$

$$C=-\frac{2d\,CO_2}{D_{CO_2}}\cdot\frac{r^2}{4}+B\ln r+C$$

CO_2

$\underline{R_0}=50\mu m$

$C(R_c)=C_0=HP$

$P=40\,mmHg$

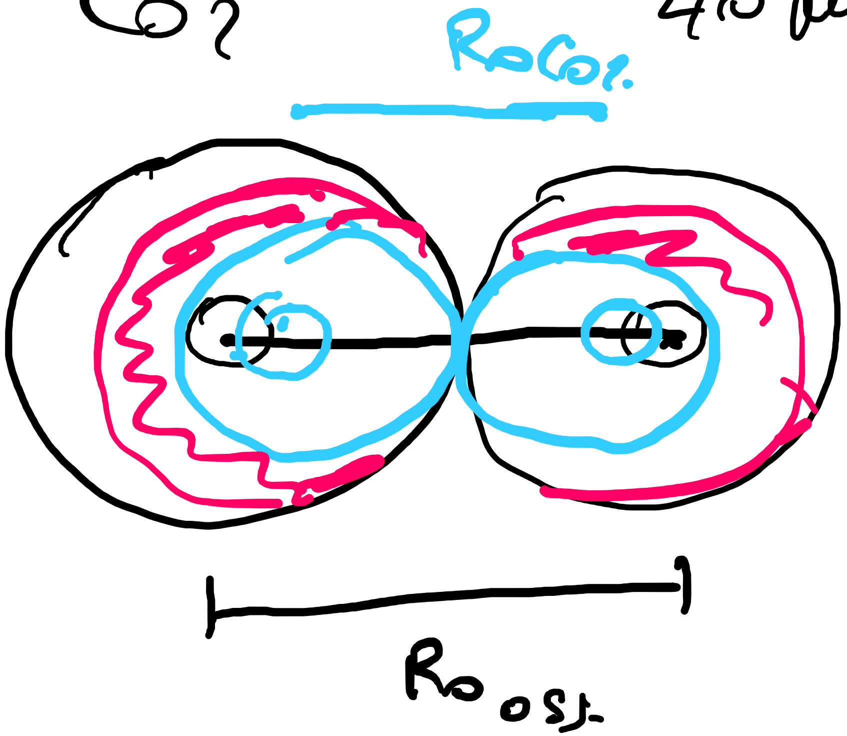
$C(R_0)=C_1=HP_1$

$P_1=45/46\,mmHg$

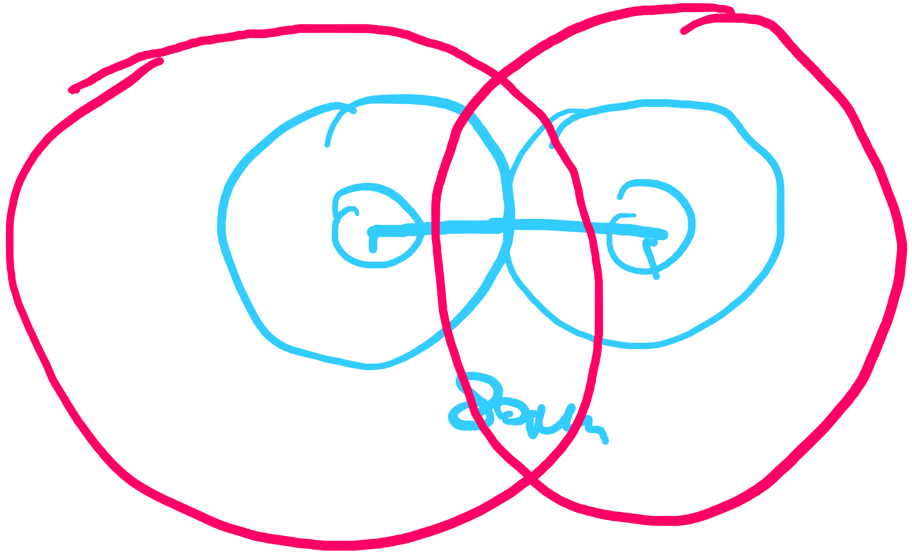
$C(0)=\phi$

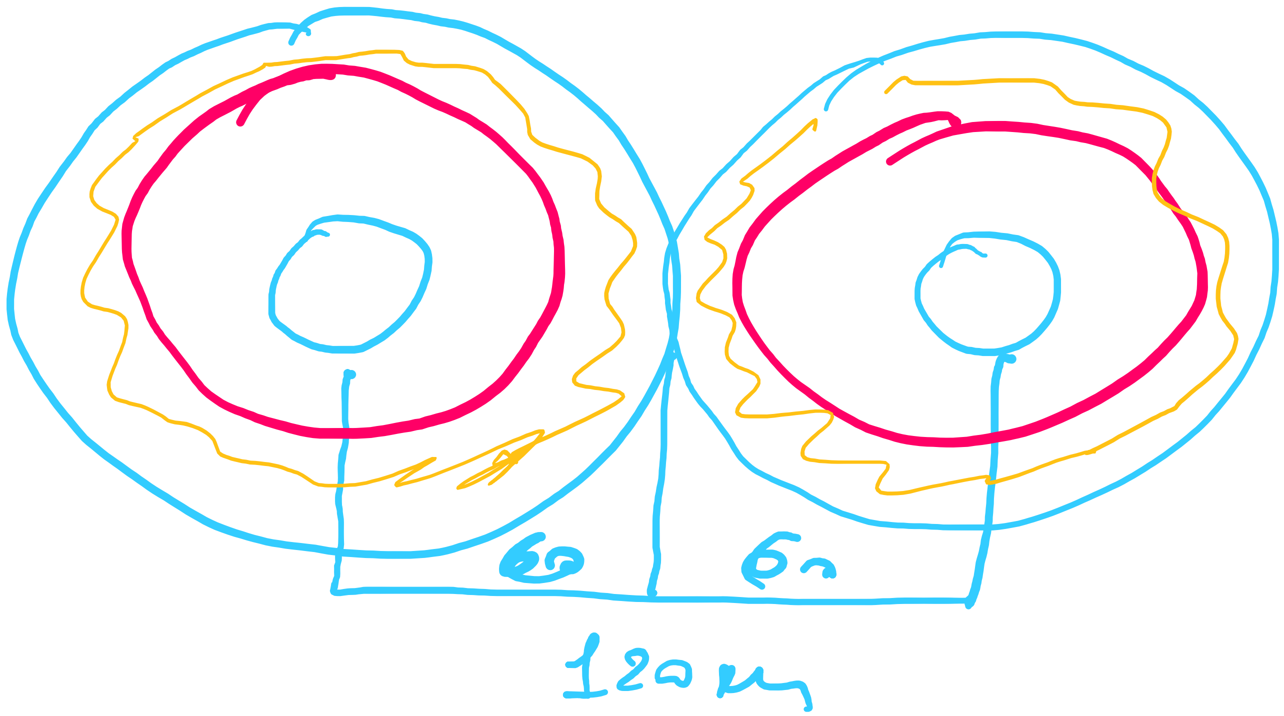
R_0 ossigeno 50 µm

R_0 CO_2 40 µm



R_0CO_2 60 µm




60
60
120 km