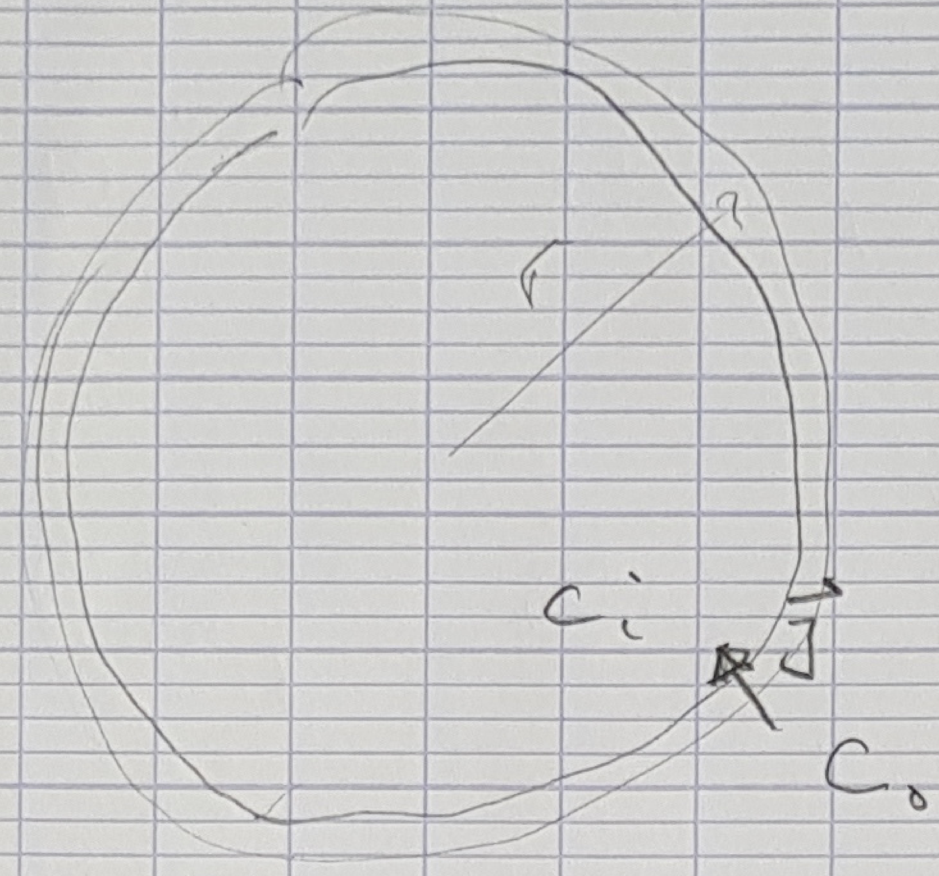
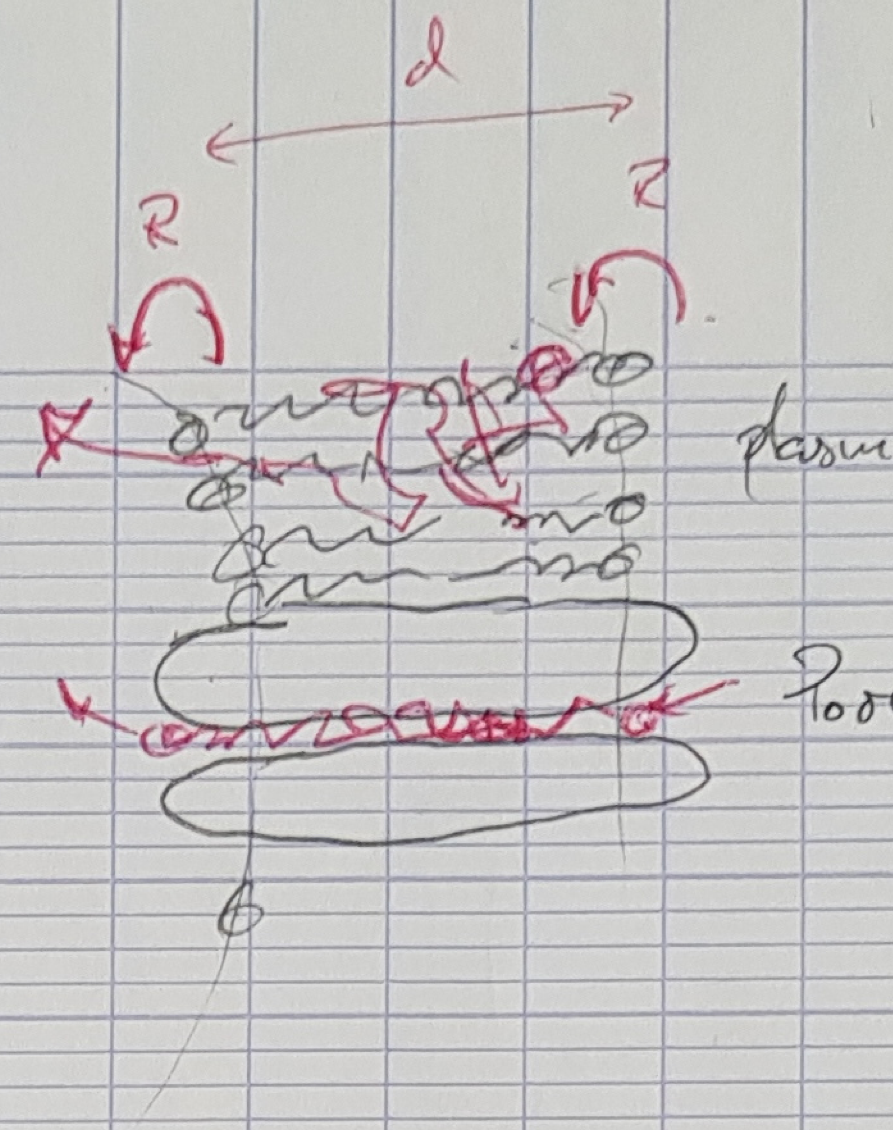
Permeation through cell membrane





$\Delta C = C_o - C_i \qquad C = \frac{N}{V}$

Flux $J = \frac{\Delta N}{A \Delta t}$ flow rate per unit area

C_o - constant

$V \frac{\partial c_i}{\partial t} = \frac{\partial N}{\partial t} = AJ$

$= -\frac{\partial \Delta C}{\partial t} \cdot V$

If plasma membrane impermeable

$J = P \Delta C \qquad P$ - permeability

$\frac{\partial \Delta C}{\partial t} = -\frac{A}{V} P \Delta C$

$\int_{\Delta C_0}^{\Delta C} \frac{\partial \Delta C'}{\Delta C'} = -\frac{A}{V} \int_0^t P \, \partial t'$

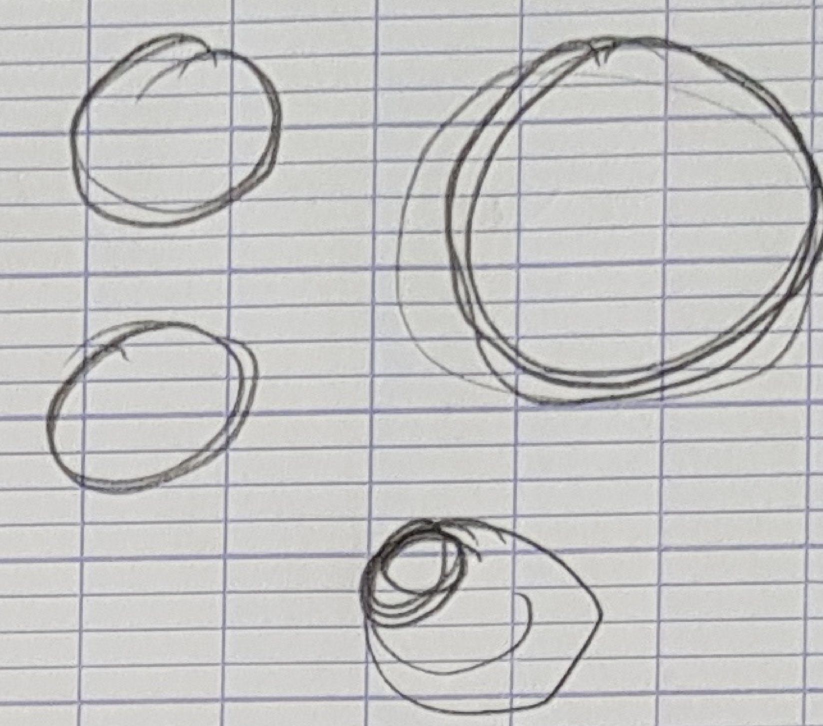
$\ln \Delta C - \ln \Delta C_0 = -\frac{PA}{V} t$

$\frac{\Delta C}{\Delta C_0} = e^{-t/\tau} \quad , \quad \tau = \frac{PA}{V}$

$A = 4\pi r^2 \qquad V = \frac{4}{3}\pi r^3 \qquad \frac{V}{A} = r/3$

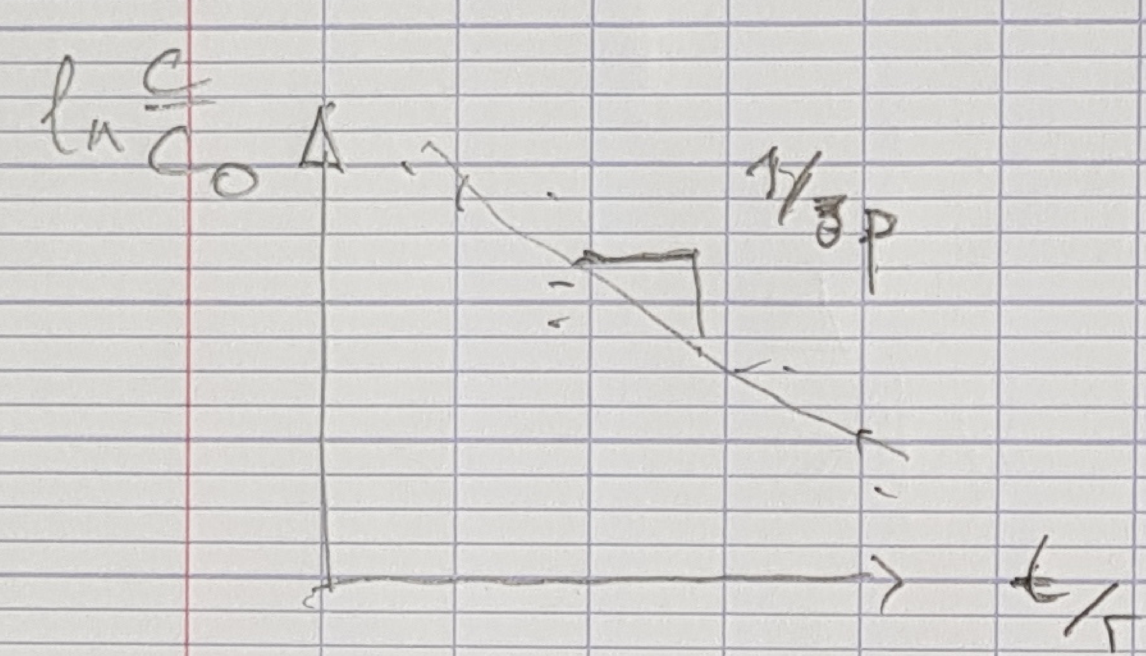
$\Rightarrow \Delta C = e^{-t/\tau} \quad , \quad \tau = \frac{3P}{r}$

Different cell sizes



Assume you could measure $c_i(t)$

How would you plot the data to extract P?

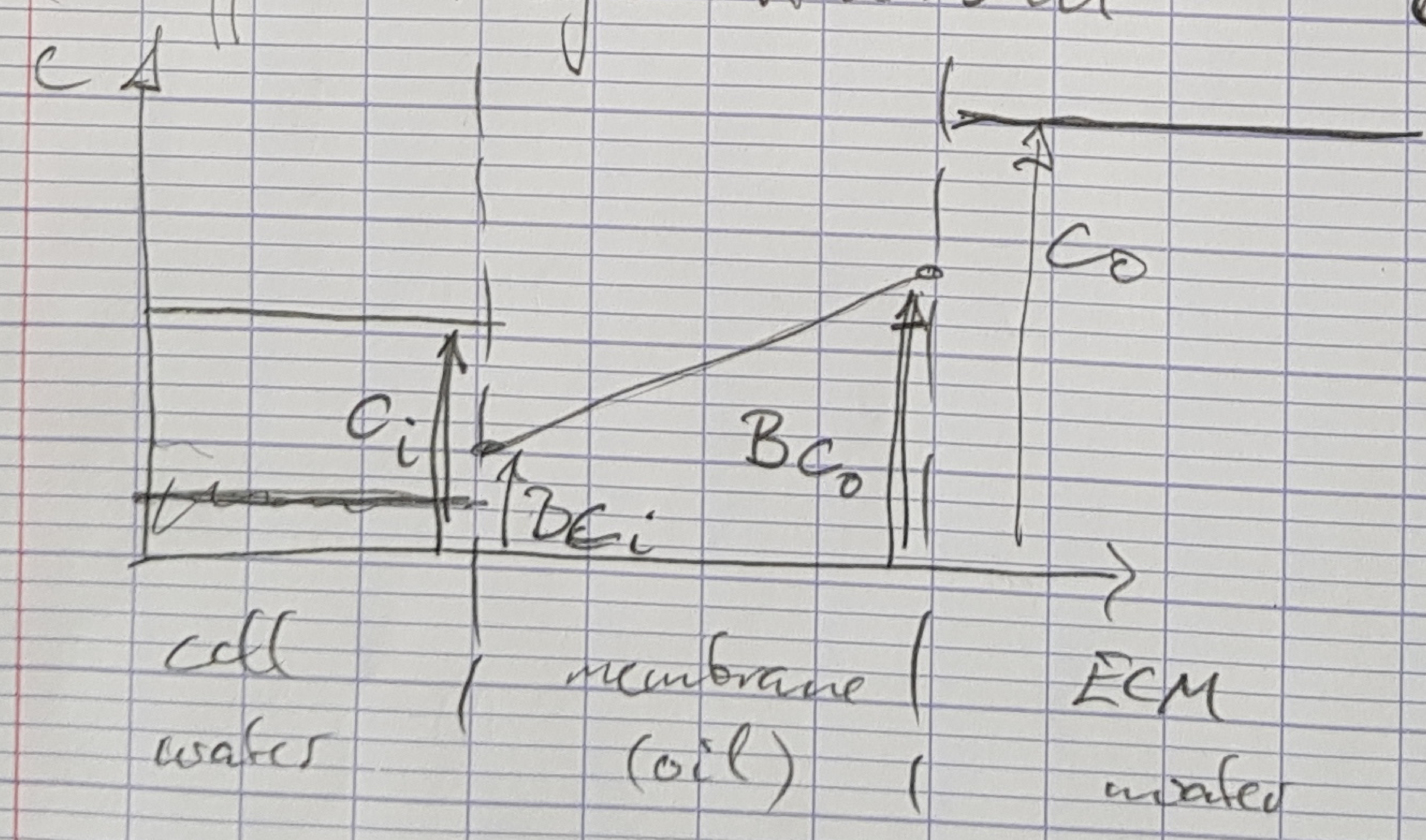


Diffusion in plasma membrane

Resistance to entry/exit + diffusion in membrane

$$J = -D \frac{\Delta c}{\Delta x}$$

{To diffuse they must dissolve $\quad c = \frac{N}{V}$ }

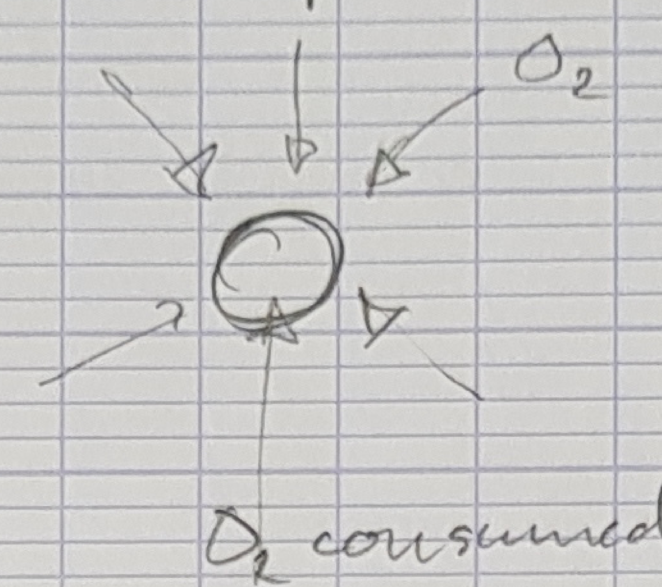


D – in oil

$$J = -D B \frac{\Delta c}{\Delta x}$$

$$J = -D \frac{B}{\Delta x} \Delta c = P \Delta c \Rightarrow P = \frac{DB}{\Delta x}$$

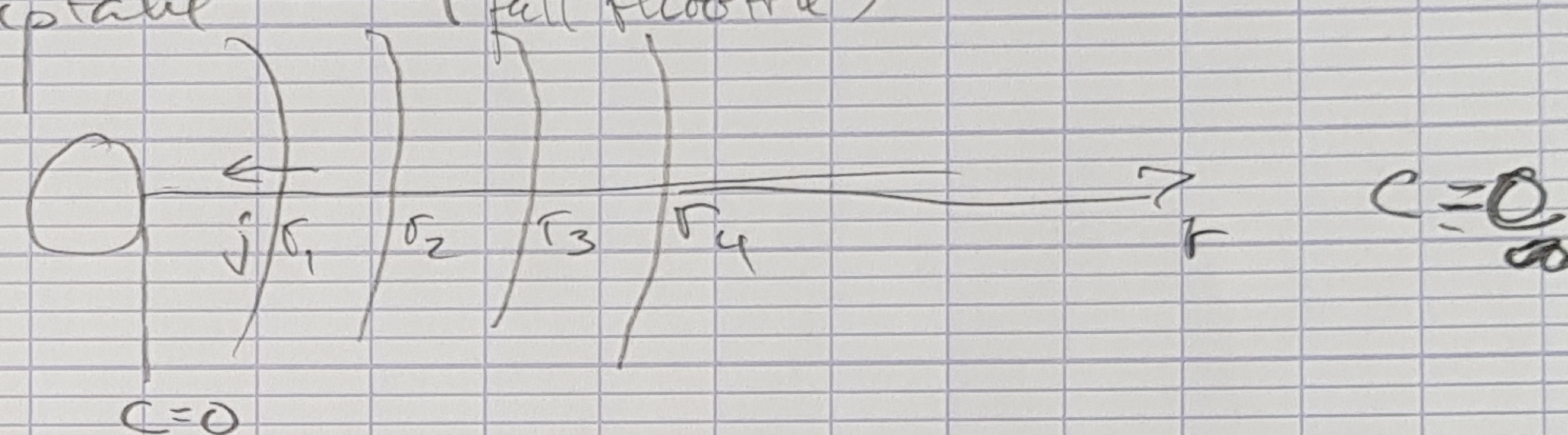
Bacterium in liquid (no motion)



Ocean : turbulence

Pond/Mud : Diffusion

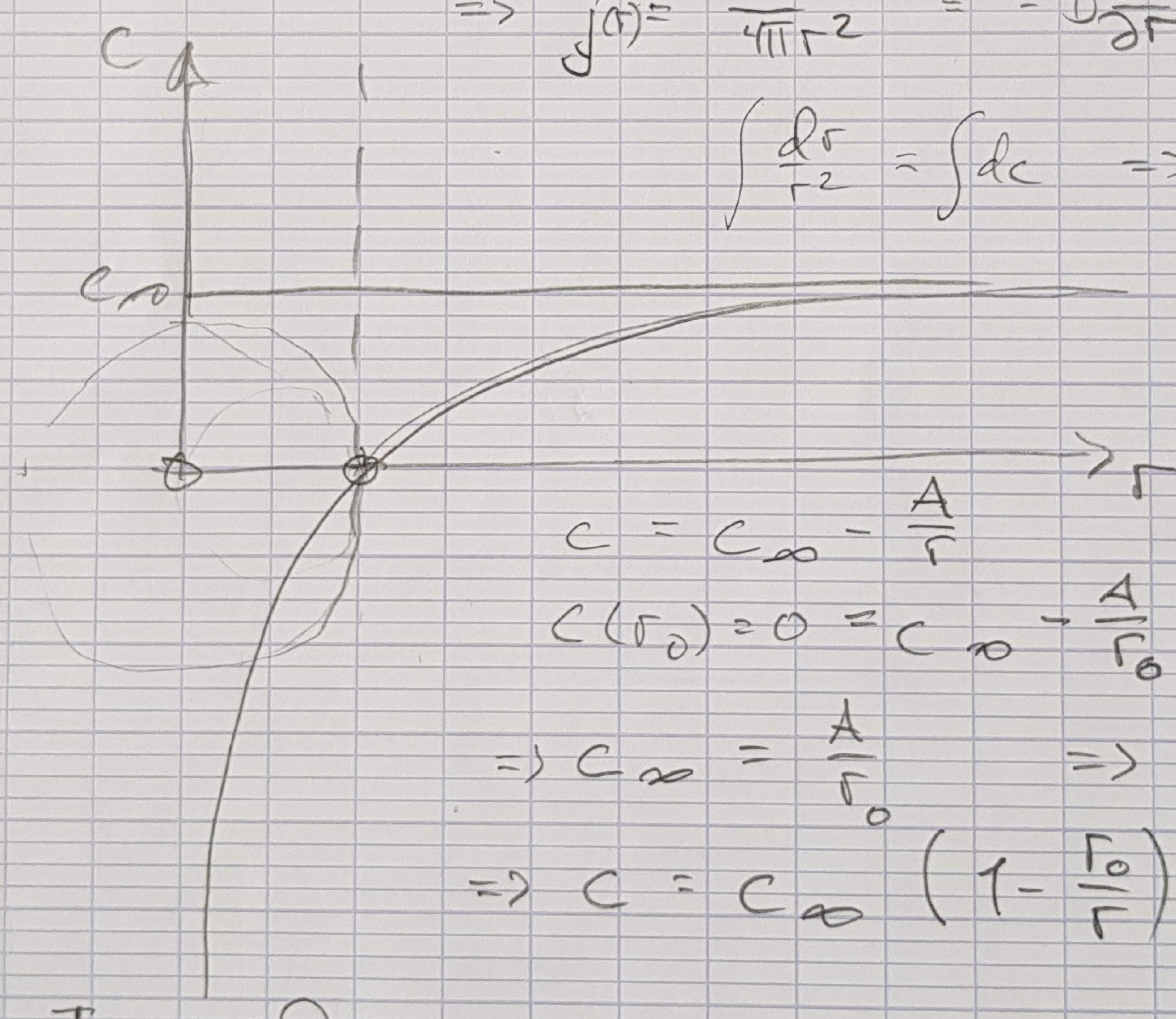
Assume instant uptake (full throttle)



$A_1 j(r_1) = A_2 j(r_2) = I$

$\Rightarrow j(r) = \frac{I}{4\pi r^2} = -D\frac{\partial c}{\partial r}$

$\int \frac{dr}{r^2} = \int dc \Rightarrow c \propto \frac{1}{r}$



$c = c_\infty - \frac{A}{r}$ A integ const

$c(r_0) = 0 = c_\infty - \frac{A}{r_0}$

$\Rightarrow c_\infty = \frac{A}{r_0} \Rightarrow A = r_0 c_\infty$

$\Rightarrow c = c_\infty \left(1 - \frac{r_0}{r}\right)$

$\frac{I}{4\pi r^2} = -D\frac{\partial c}{\partial r} = +D c_\infty \frac{r_0}{r^2}$

$\Rightarrow \boxed{I = 4\pi D c_\infty r_0}$

$r_0 \sim 10^{-6}\,m$

$D \sim 10^{-9}\,m^2/s$

$c_\infty \sim 0{,}2\ mol/m^3$

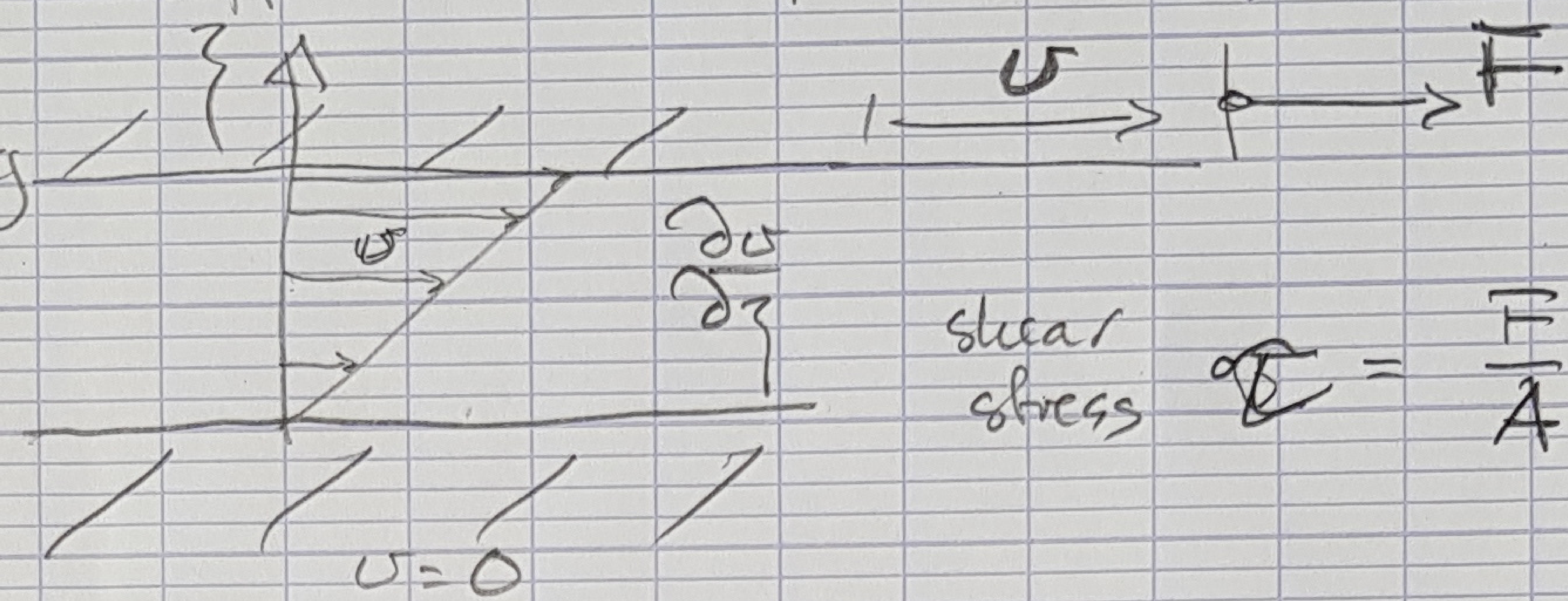
Gjør your turn 4F s139 sammen

Viscous drag

Drag

Friction coefficient of sphere $\quad \xi = 6\pi\eta R \quad$ Stokes

Viscosity



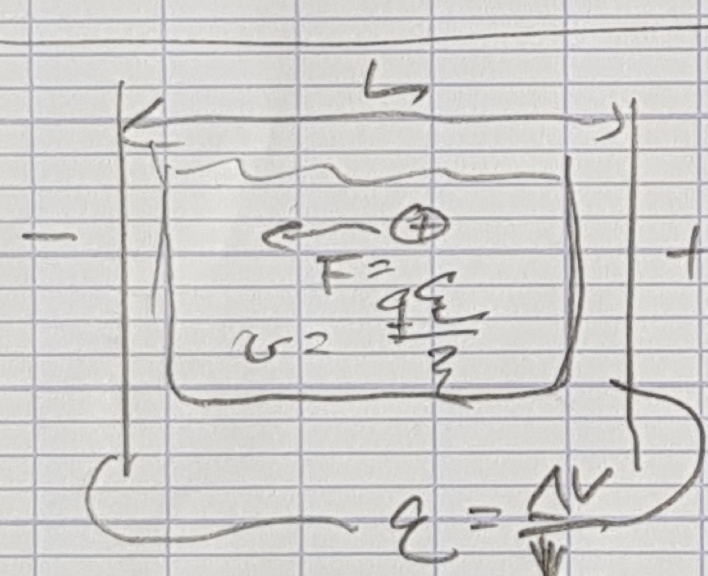
shear stress $\tau = \frac{F}{A}$

Definition viscosity $\quad \tau = \eta \frac{\partial v}{\partial z} \quad$ Dynamic viscosity

Kinematic viscosity $\quad \nu = \frac{\eta}{\rho}$

Einstein relation $\quad \xi D = 6\pi\eta D R = k_B T$

Diffusion, ions potentials



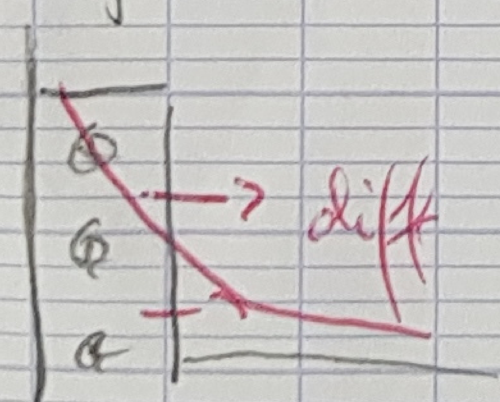
$F = q\mathcal{E}$

$v = \frac{q\mathcal{E}}{\xi}$

Flux of ions j: $A j = \frac{dN}{dt} = \frac{A\,d(x c)}{dt} = \frac{A c\,dx}{dt} =$

$\Rightarrow j = c \cdot v = \frac{c q \mathcal{E}}{\xi}$

Charge will build up on walls ⊥ flow

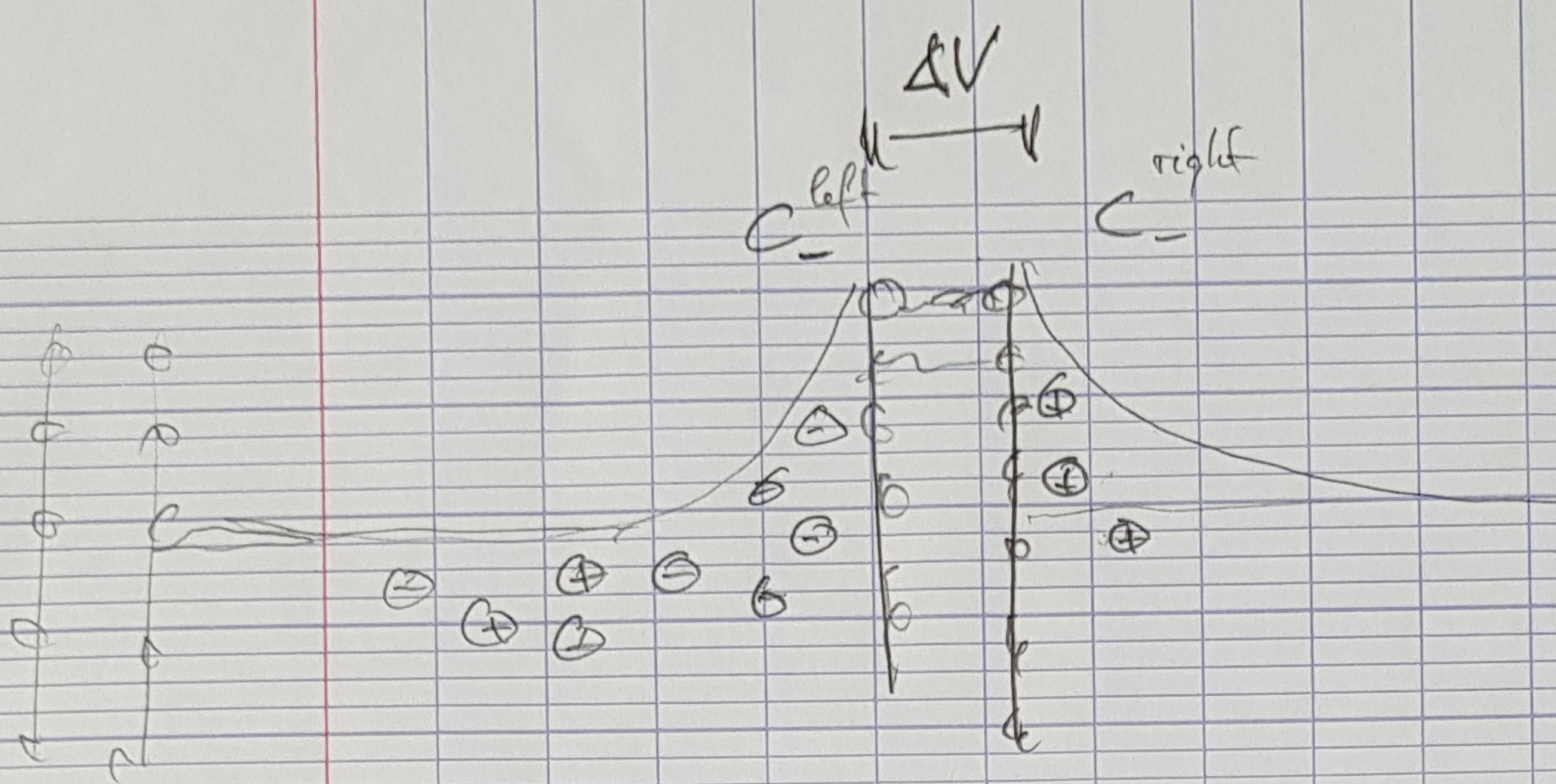


$j = c v - D\frac{\partial c}{\partial x}$

$= \frac{c q \mathcal{E}}{\xi} - \frac{k_B T}{\xi}\frac{\partial c}{\partial x}$

equil: $j = 0$ $\qquad \frac{q\mathcal{E}}{kT} = \frac{1}{c}\frac{\partial c}{\partial x}$

$\ln \frac{c_{right}}{c_{left}} = \frac{q\mathcal{E}}{kT} L = \frac{q\Delta V}{kT}$



$$\frac{c_{left}}{c_{right}} \approx 10 \qquad \frac{k_B T}{e} = \frac{1}{40} V$$

$$\ln \frac{c_l}{c_r} = 40 \cdot \Delta U$$

$$\frac{2{,}3}{40} V \approx 58 \text{ mV} = \Delta U$$

Where does $\frac{c_{left}}{c_{right}} \approx 10$ come from?

For wednesday: Life at low Reynolds number, Purcell 1977

Lars p7: How corkscrew propels → p9 Datsun is Saudi Arabia

Jasmin p9: Propulsion efficiency → end

Kent Start → p4 qualify as a low Reynolds number swimmer
+ p6 – p7 real animals

Eva p4: swimming

Jeg ser på om vi kan få et bedre datasett + chemotaxis