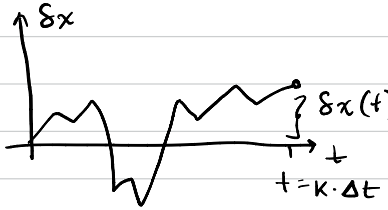
Lecture 31

Last Time: Diffusion, force = F_{random}



$$\delta x(t) = \sum_{j=1}^{K} \Delta x_j$$

= gaussian random variable if K is large enough

$$\sigma^2 = \sum_j \sigma_j^2$$

$$\langle \delta x^2 \rangle = K \langle \Delta x^2 \rangle = \frac{t}{\Delta t} \langle \Delta x^2 \rangle$$

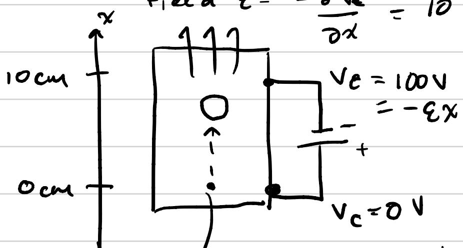
$$\langle \delta x^2 \rangle = 2D \cdot t \quad \text{where} \quad D = \frac{\langle \Delta x^2 \rangle}{2 \Delta t} \quad \left(\frac{m^2}{s}\right)$$

in one dimension

Today: Drift velocity and flux

ex: protein gel electrophoresis

field $\mathcal{E} = -\frac{\partial V_e}{\partial x} = 10$ V/cm



protein spot ⊕ ; charge $Q = nz$ coloumbs/mole

How fast does protein move?

$$E = TS - PV + \mu n + V_e Q$$
$$= TS - PV + \mu n - \mathcal{E}x \cdot nz$$

$$\Rightarrow \frac{\partial E}{\partial n} = \mu \Rightarrow \frac{\partial^2 E}{\partial n \partial x} = \frac{\partial \mu}{\partial x}$$

$$\Rightarrow \frac{\partial E}{\partial x} = -F_{appl} = -\mathcal{E}nz$$

$$\frac{\partial^2 E}{\partial x \partial n} = -\mathcal{E} \cdot z$$

But from calculus, $\frac{\partial^2 f}{\partial x \partial y} = \frac{\partial^2 f}{\partial y \partial x}$

$$\Rightarrow -\frac{\partial \mu}{\partial x} = \mathcal{E} z$$

$$\left(\frac{kJ}{\text{mole} \cdot \text{meter}}\right) = \left(\frac{\text{Newtons}}{\text{mole}}\right)$$

$-\frac{\partial \mu}{\partial x}$ is the driving force per mole

There are 3 different forces applied to the protein:

$$F = F_{appl} + F_{random} + F_{friction} = ma$$

friction ~ # of collisions ~ velocity

$$F = -\frac{\partial \mu}{\partial x} + F_{random} - \gamma \cdot v \approx 0$$

friction coefficient p. 31

Einstein's mobility $u = \frac{1}{\gamma} = \frac{D}{KT}$

If we neglect (for now) F_{random},

$$-\frac{\partial \mu}{\partial x} = \gamma v$$

$$\Rightarrow \varepsilon z = \gamma v \Rightarrow v_{drift} = \frac{\varepsilon \cdot z}{\gamma}$$

v → increases w/ field ε
→ " " protein charge
→ " " mobility ($u = \frac{1}{\gamma}$)

$$\gamma = 6\pi \cdot \eta \cdot r$$

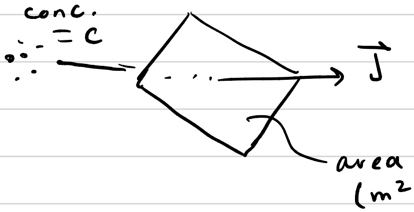
viscosity (η), radius of protein (r)

ex: hw 6.2 $\gamma = \frac{KT}{D}$ or $\frac{RT}{D}$

per molecule

$R = A \cdot K$
per mole

Flux =



$$J\left(\frac{\text{moles}}{m^2 \cdot s}\right) = \overset{m/s}{v} \cdot \overset{\text{moles}/m^3}{C}$$