Active Matter Physics

Prepare the solutions for the seminar on 2024.4.24

Exercise Sheet 2

2.1

For each of the following spherical particles suspended in water at $T = 20$ °C:

1. a grain of sand, 100 μm in diameter, density of 2200 $\mathrm{kg \cdot m^{-3}}$,
2. a polymer particle, 1 μm in diameter, density of 1050 $\mathrm{kg \cdot m^{-3}}$,
3. a virus, 100 nm in diameter, density of 1020 $\mathrm{kg \cdot m^{-3}}$,

- calculate the sedimentation velocity,
- calculate the diffusion coefficient,
- estimate the time the particle takes to diffuse a distance equal to its own diameter.

(Additional data: The viscosity of water is $1.002 \cdot 10^{-3}$ Pa · s and the density of water is 1000 $\mathrm{kg \cdot m^{-3}}$).

2.2

Consider N indistinguishable ideal particles that are moving in a gravitational field with potential energy $E_{\mathrm{pot}} = mgz$, where m is the mass of a particle and g is the gravitational constant. Using the Boltzmann distributed particle density $n(\mathbf{r}, \mathbf{p})$ derive the barometric height formula describing the number of particles $N(z)\,\mathrm{d}z$ with z-coordinate between z and $z + \mathrm{d}z$.

2.3

A four-residue protein can take on the four different conformations shown in Figure 1. Three conformations are open and have the energy ϵ ($\epsilon > 0$), and one is compact and has the energy zero.

- At temperature T, calculate the probability p_{o} of finding the molecule in an open conformation. Calculate the probability p_{c} that it is compact.
- Determine what happens to the probability p_{c} calculated in the previous bullet point in the limit of very large and very low temperatures.
- Calculate the average energy of the molecule at temperature T.

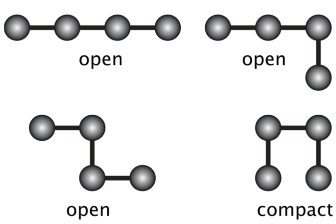

Figure 1: Toy model of protein folding showing four configurations.