LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

biophysikalische Chemie/molekulare Biophysik
Wintersemester 2020/2021

Homework IV

Department Chemie
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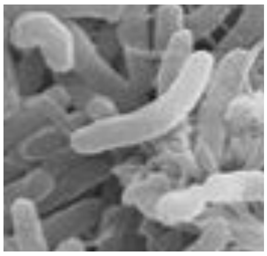
Homework is due at the *beginning* of Lecture (8:15AM) on Thursday, February 4th, 2020.

1. We approximate a Vibrio cholerae (shown in the figure) as a sphere with a diameter of 2.8 µm. If the Vibrio cholerae is swimming at a speed of 5.1 µm/s:



   a) What is the Reynold's number of the bacterium?
   b) What is the viscous drag on the bacterium?
   c) How far will the bacterium coast when it stops swimming?

2. A fictional motor protein takes steps of 3 nm using ATP hydrolysis as the energy source. Assume a standard free energy of ATP hydrolysis of -54×10^{-21} J and typical cellular concentrations of ATP, ADP and P_i (1 mM, 10 µM, and 1 mM respectively).
   Calculate the stalling force of this motor.

3. A 1.0 µm diameter bead in water is held by an optical trap at room temperature. The bead breaks out of the trap at a maximum flow of 180 µm/s being applied to the sample cell in a direction perpendicular to the laser beam of the trap. Calculate the trap's efficiency at the maximum force assuming a laser intensity of 30 mW. (The viscosity of water at 20° C is 1.002 centipoise, the refractive index of water is 1.33.).

4. For a freely jointed chain, the radial end-to-end distribution function is given by:

$$W(r)dr = \left(\frac{\beta}{\sqrt{\pi}}\right)^3 e^{-\beta^2 r^2} 4\pi r^2 dr \quad \text{where} \quad \beta = \left(\frac{3}{2nl^2}\right)^{\frac{1}{2}}$$

   Starting with the given distribution function, show that the average end-to-end distance is given by:

$$\langle r^2 \rangle = nl^2 .$$

5. Double-stranded DNA has a persistence length of 53 nm.
   A) Calculate the average end-to-end distance of a 47365 bp piece of dsDNA using the Worm Like Chain Model.

   B) If we describe the DNA with a Freely Jointed Chain model, what is the number and length of the Kuhn segments?

6. Anisotropy Measurements
   A) From the definition of anisotropy, show that the anisotropy of a sample with two species is given by the sum of the individual anisotropies weighted by their fractional intensities.

B) If the emission dipole is rotated an angle β from the absorption dipole, show that the measured anisotropy from an isotropic, non-rotating sample excited with linear polarized light is given by:

$$r = \frac{2}{5}\left(\frac{3\cos^2\beta - 1}{2}\right)$$

C) The angle between the absorption dipole and the emission dipole of a fluorophore is 12.9°. What is the maximum anisotropy that one can measure with this sample?