

BIOENG 455 Practise Test 1

1) The virial expansion of a gas is an expansion of pressure in powers of the number density $\rho = N/V$:

$$P = \rho k_B T (1 + B_2 \rho + B_3 \rho^2 + \dots)$$

where the $B_2, B_3, \dots$ are virial coefficients, and may be functions of temperature but not density. What are the dimensions (M, L, T) of B_2 and B_3 ? (1 point)

2) If the potential difference across a cell's plasma membrane is 80 mV, what is the magnitude of the electric field across it? (include units) (1 point)

3) Consider a real polymer as a linearly-connected chain of N spherical monomers of diameter a :

a) If the polymer consists of $N = 20,000$ monomers of diameter $a = 1$ nm and has a Kuhn length of $l_k = 3$ nm, how many Kuhn lengths are there in the equivalent phantom chain? (2 points)

b) What is the average end-to-end length ($\sqrt{\langle R_{ee}^2 \rangle}$) of the polymer? (2 points)

4) State the Equipartition theorem (making clear the key assumptions) (3 points)

5) Write down the full expression for $\langle R_{ee}^2 \rangle$ of a real polymer before making the freely-jointed chain assumption? What property of the polymer does the second term represent? (2 points)

6) The two strands of DNA are held together by H-bonds that have an energy ~ 5 kBT per base pair and the base pairs are ~ 0.3 nm apart along the strands. If the DNA is 10^6 base pairs long and has a Kuhn length of 300 nm, what is its average end-to-end distance? And what is the total energy of all the H-bonds (4 points)

7) Consider an intrinsically disordered protein as a phantom chain of N monomers that are spheres of radius a . What is the ratio of the volume of all the monomers to the volume occupied by the fluctuating chain? What is the actual value if $N = 200, a = 1$ nm (2 points)