

BIOENG 455 Practise Test 1

1) The van der Waals equation of state for a gas of interacting particles is:

$$(P + a N^2/V^2) (V - N b) = N k_B T$$

What are the dimensions (M, L, T) of the constants a and b? (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 $N = 20000$ 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) (4 points)

5) Draw a cartoon of a two-tailed phospholipid and identify the three physical quantities that make up Israelachvili's packing parameter. How would the packing parameter change if one tail were removed with no other changes to the molecule? (2 points)

6) The two strands of DNA are held together by H-bonds that have an energy $\sim 5 k_B T$ 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)