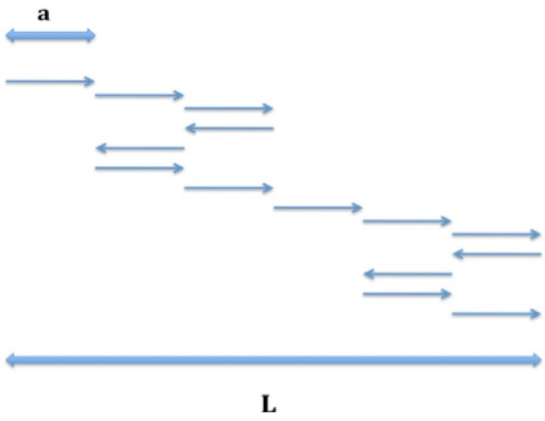
PHYS 234: Recitation 2
(Quiz: Feb 5, 2020)

1. **Estimation:** How many molecules are in this sheet of paper?
Clearly state your assumptions and how you came to the numbers you estimate.

2. **Essay:** State the second law of thermodynamics in words. Then, address the following question: The second law of thermodynamics is often called a "probabilistic law." How can something be a law if it only talks about probabilities? Support your answer with an example.

3. A very simple model of a polymer like DNA is a one-dimensional chain consisting of N links, each with length a. Each of the links may be freely oriented to the right or left with 50% probability, just like a coin toss. Call the number of elements oriented to the right n_R and the number of elements oriented to the left n_L, such that $N = n_L + n_R$.

A. Refer to the figure at the right, in which one possible conformation of polymer links is illustrated (but where the individual links have been distributed vertically for clarity). For the example drawn, what are the values of N, n_R, and n_L?



B. For the example drawn, what is the value of the end-to-end extension L in terms of the link length a?

C. Write down an expression for L in terms of n_R, n_L, and a. Make sure that for the particular configuration drawn, your expression reduces to your answer in B.

D. Write down an expression for the number of possible arrangements W as a function of N and n_L or n_R. Explain your reasoning. (Hint: Recall the coin toss problem from Recitation 1.)

E. What would the state of minimum entropy of this polymer look like? Explain.

F. What would the state of maximum entropy of this polymer look like? Explain.

4. A 25% efficient electric power plant produces one gigajoule of electric energy per second and discharges waste heat into the ocean. Suppose the waste heat could be used to heat homes during the winter instead. A typical American home requires 20 kW for heating. How many homes could be heated with the waste heat of this one power plant?

5. When enough energy is added to carbon dioxide gas, the molecules dissociate into one carbon and two oxygen atoms ($CO_2 \rightarrow C + 2O$).

A. If one mole of carbon dioxide dissociates at standard temperature and pressure, what is its change in volume ΔV? Treat all gases as ideal.

B. Dissociation requires two sources of energy: (i) energy $p\Delta V$ to increase the volume, where p is pressure; and (ii) energy $\Delta E = 1600$ kJ/mol to dissociate the bond. Which factor is larger here?