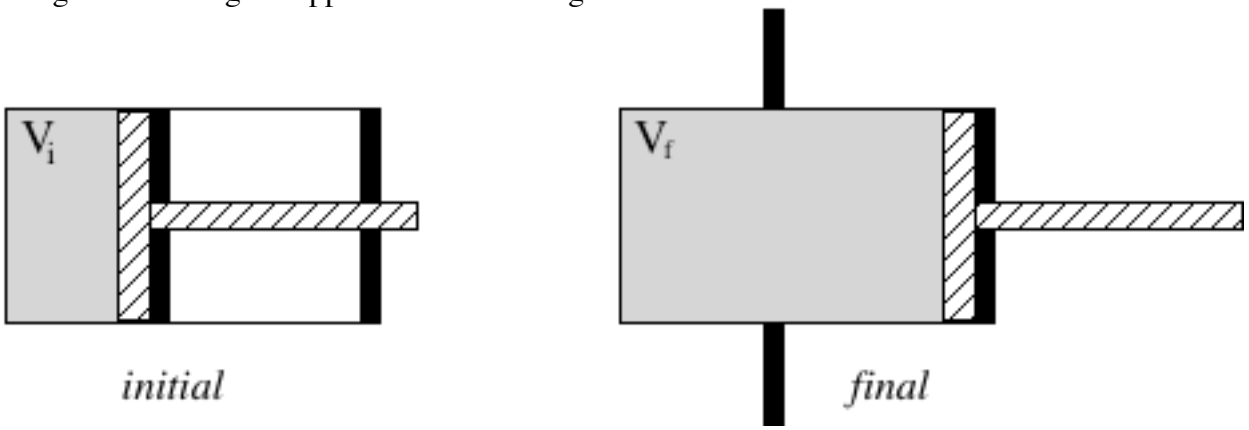
Problem Set 8: The Second Law of Thermodynamics — Due Sept 23, 2008

The goal of these problems is show you that the property which we call entropy s a useful predictor of whether a process will be spontaneous. In many of the following problems , you will calculate the entropy for processes which you know happen spontaneously.

1. State the second law of thermodynamics.

2. Imagine an ideal gas trapped in the following device:



The ideal gas has an initial volume of V_i as shown on the left. The piston is prevented from moving by the first set of black stops. This entire device is contained inside a container. During this experiment, the temperature T inside the container does not change. The first set of stops are removed, and the piston spontaneously moves to the back of the device in a reversible process. The final volume of the ideal gas is V_f.

(a) What is ΔU for this expansion?
(b) What is Δw for this expansion? (Calculate the integral completely)
(c) What is Δq for this expansion?
(d) What is ΔS for this expansion?
(e) Using the expression you calculated in part (d), is it ever possible for ΔS to be negative for this process?

3. A flask containing liquid benzene (C_6H_6) at its freezing point (5.5°C) is brought into contact with an enormous ice-water bath at 0°C.
   (a) What spontaneous change happens to the benzene in the flask?
   (b) A total of 1 mole of benzene was in the flask. The heat of fusion of benzene is 30.3 cal/g. How much heat is liberated when the benzene freezes?
   (c) What is the entropy change for the benzene (be careful: the temperature of the benzene does not change when it freezes).
   (d) All of the heat released by the benzene passes into the ice-water bath. Calculate the entropy change for the ice-water bath.
   (e) Once again, we can calculate the overall entropy change for this process by adding together the entropy changes for the bath and for the benzene in the flask. What is the entropy change of this process?

4. One mole of a monoatomic ideal gas is heated reversibly from 10°C to 20°C in a constant volume container.
   (a) What is the change in entropy for this reversible process?
   (b) What would be the change in entropy if the heating were performed irreversibly.

5. Do living organisms, which grow and proliferate spontaneously, obey the second law of thermodynamics? Why or why not?

An optional problem set on the 3 laws of thermodynamics is available at
http://www.bmb.psu.edu/courses/bmb428/problemsets/bmb428_problemsete1.pdf
(can also be accessed through http://www.bmb.psu.edu/courses/bmb428/bmb428_assignments.html)