This problem set is designed to help you understand Entropy, and to give you practice in using Entropy to solve problems.

1. 1 kg of ammonia is contained in one half of a tank with rigid walls, separated from the other half of the tank, which is evacuated, by a thin membrane. The tank's total volume is 500 L and the temperature of the gas is 200 °C. Can this gas be treated as an ideal gas? The membrane bursts and the gas expands to fill the entire tank. Has the temperature of the gas changed? Determine the change in entropy of the gas by getting from state 1 to state 2 by each of the following compound processes:
   a. Totally reversible isothermal expansion. Assume the gas expands by very slowly pushing a frictionless piston (in place of the membrane). Heat transfer is between the tank and a thermal reservoir at 200 °C).
   b. Internally reversible, externally thermally irreversible isothermal expansion. Assume the gas expands by pushing the piston as above. Heat transfer between the tank and a thermal reservoir at 300 °C is internally thermally reversible but externally irreversible.
   c. First, the gas expands reversibly and adiabatically by pushing a piston as above, followed by totally reversible heat transfer between the gas and a series of temperature reservoirs (infinitely many) such that the reservoir in contact with the gas always has the same temperature as the gas.

2. Nitrogen gas sits inside a cylinder. The piston is moved in and out by varying the external pressure $P_{ext}$. The motion is so slow, and the materials involved are such good heat conductors, that the temperature everywhere remains undetectably different from room temperature 300K at all times. There is friction between the piston and the cylinder; the force of friction is constant and equal to 100 N. The area of the piston is 0.01 m². (the setup of this problem is the same as #7 from Problem Set #2.)
   a. The piston/cylinder/gas system goes through a cycle where $V$ goes from 1 L to 0.5 L and back to 1 L. The $N_2$ is initially ($V = 1$ L) at 300K, 400 kPa. Calculate $\Delta U$ and $W$ during the compression process. Remember that the piston is part of the system. What is $Q$?
   b. Now take the system to include only the gas. What are $\Delta U$ and $W$ during compression? What is $Q$? This value for $Q$ is not the same as above. Explain the difference and find the change in entropy of gas alone.
c. Do parts a) and b) for the expansion of the gas (from $V = 0.5 \text{ L}$ to $V = 1 \text{ L}$).

d. Using the system from part a) how much does the entropy of the surroundings change during the entire cycle? Explain briefly.

3. Sonntag 8.31

4. Sonntag 8.51

---End of problems---