Physics 301
Homework #5

Due Friday October 3.

1. An ideal gas is in thermal equilibrium with a heat reservoir which is at a temperature T_1. The gas is expanded isothermally (At constant temperature) from volume V_1 to V_2.

   (a) What is the entropy change of the gas?

   (b) What is the corresponding entropy change of the heat reservoir?

   (c) What is the total entropy change, *i.e.*, the entropy change of the joint system? Is this in agreement with the second law?

2. The specific heat (c) is the special name given to a substance's heat capacity (at constant pressure) per gram. In other words

   $$đQ = dE_{\text{THERMAL}} = mc\,dT$$

   where m is the mass and dT the infinitesimal change in temperature. Liquid water's specific heat can be considered a constant with value $4.2 J/g/^\circ C$ (Joules per gram per degree Celsius).

   (a) Using water's specific heat, calculate the number of degrees of freedom per water molecule, $\nu = f/N$.

   HINT: The atomic mass of water is $18\,g/mole$ where $1 mole = 6.02 \times 10^{23}$particles. Also, assume that for water $\chi = 1/2$.

3. (a) $1000\,g$ of water at $20^\circ C$ is in contact with a heat reservoir at $80^\circ C$. What is the change in entropy of the **entire** system after equilibrium is re-established?

   (b) If the $1000\,g$ of water at $20^\circ C$ is heated by successively placing the water into contact with heat reservoirs at $50^\circ C$ then $80^\circ C$ (and waiting for equilibrium to re-establish itself before changing reservoirs), what is the change in entropy of the entire system?

   HINT: It is important to use the absolute Kelvin temperature here. $Kelvin = Celsius + 273$. Water's heat capacity, however, has the same value for both Celsius and Kelvin since the change in temperature is the same for both scales.