**PHYS 1220-02 Group Work Sheet**
**Entropy and Equilibrium**

1. 500 grams of crushed ice melts in a room maintained at 26.85°C.
   a. What is the entropy change of the ice? Assume that while the ice is melting, its temperature is steady at 0°C. You may want to know that the latent heat of melting ice is 334 kJ/kg.

   b. What is the entropy change of the air in the room? Remember that its temperature is steady at 26.85°C.

   c. What is the entropy change of the universe?

2. An Airgas cylinder contains 49 liters of compressed argon at 18 MPa and 300 K. It freely expands to a pressure of 79 kPa (approximately Laramie air pressure). What is its change in entropy? Assume that the argon is an ideal gas. You may want to know that $R = 8.31446$ J/(mol·K) and $k = 1.380649 \times 10^{-23}$ J/K.

3. A finite object of mass $m$ and specific heat capacity $c$ receives a quantity of heat $Q$.
   a. By what amount $\Delta T$ does its temperature increase?

   b. What is the temperature increase $dT$ of a body of mass $m$ and specific heat capacity $c$ receiving a quantity of heat $dq$?

   c. In part b, you found $dT$ in terms of $dq$. Invert your formula to express $dq$ in terms of $dT$.

   c. As the body absorbs heat, its temperature changes, so calculating its entropy change isn't a simple matter of dividing heat by absolute temperature. For infinitesimal heat inputs $dq$ causing infinitesimal temperature increases $dT$, however, we can claim that $dS = dq/T$. Integrate $dS$ from $T_i$ to $T_i + \Delta T$ to find the entropy change resulting from absorbing quantity $Q$ of heat.

4. Imagine a brass artifact of mass $m_1$ initially at high temperature $T_{1i}$ placed into a beaker containing mass $m_2$ of water initially at low temperature $T_{2i}$. As heat flows away from the brass, its entropy decreases; as heat flows into the water, its entropy increases.
   a. As the brass, with mass $m_1$, specific heat capacity $c_1$, and initial temperature $T_{1i}$, loses heat $Q$, what is its entropy change?

b. As the water, with mass $m_2$, specific heat capacity $c_2$, and initial temperature $T_{2i}$, absorbs heat $Q$, what is its entropy change?

c. When the brass is immersed in the water, heat $Q$ flows from the brass to the water. What is the entropy change of the universe? Express as a function of $Q$.

d. Now that you have a formula for the entropy change of the universe as a function of $Q$, the heat exchanged between the two items in contact with each other, find the formula for $Q$ that maximizes entropy $S$. This is a max-min problem.

   i. First, take the derivative of $S$ with respect to $Q$, $dS/dQ$.

ii. Then, find the $Q$ at which this derivative is zero.

e. Now that you have found the heat exchange that maximizes entropy, find the formulas for

i. The final temperature of object 1 (the initially hot brass).

ii. The final temperature of object 2 (the initially cold water).