

**PHYS 324 – Thermodynamics**  
Spring 2008

**Homework 5:** (due Feb 20<sup>th</sup>)

- (a) Determine the total entropy change per cycle for a heat engine operating between two reservoirs (one hot and one cold).  
  
(b) Use the second law ( $\Delta S_{total} \geq 0$ ) to show that the maximum possible efficiency of the engine is given by the following equation:

$$\eta_{max} = 1 - \frac{T_C}{T_H}$$

where  $T_C$  is the temperature of the cold reservoir and  $T_H$  is the temperature of the hot reservoir.

- Determine the molar entropy change for an ideal gas as it expands isothermally from  $V_i$  to  $V_f$ . Determine the total change if the process is quasi-static and the gas slowly pushes out a piston doing work (super genius little demon). Repeat if the gas undergoes free expansion into a vacuum so that no work is done (stupid little demon).
- Using the Clapeyron equation, estimate the boiling and melting points of water ( $\Delta \bar{H}_{boil} = 40,647$  J/mol,  $\Delta \bar{H}_{melt} = 6008$  J/mol) in Denver. (Hint: The molar volumes can be determined from the densities and the molecular weight.)
- The molar heat capacity of solid aluminum is a weak function of temperature:

$$\bar{C}_P = (20.7 + 12.4 \times 10^{-3} T) \frac{J}{K \cdot mol} \text{ for } 300 \text{ K} < T < 900 \text{ K}.$$

Suppose  $c$  grams of aluminum at temperature  $T_c = 600 \left(1 - \frac{\theta}{2}\right)$  K are put into thermal contact with  $h$  grams of aluminum at  $T_h = 600 \left(1 + \frac{\theta}{2}\right)$  K. Where  $\theta$  provides information about the initial temperature difference b/w the two aluminum blocks.

(a) Calculate an expression for the final temperature as a function of the ratio  $c/h$  and  $\theta$  ( $0 < \theta < 1$ ).

(b) Plot the change in total molar entropy of aluminum as a function of  $\theta$  for values

$$\frac{c}{h} = \frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}, 1$$

[Hint: Consider the two masses together as composing an isolated system. You may want to use Derive or Maple since the integral in (a) is not fun. Also, do not try to write out the expression for (b). It is SUPER messy. Just generate the plot using Derive or Maple or whatever you can find.]