Massachusetts Institute of Technology
Thermodynamics of Materials

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Problem Set 4: Due Mon. Oct. 15, Before 5PM in in 13-5114

Exercise 4.1

Let the molar internal energy and molar entropy of an ideal gas at standard temperature and pressure be $\overline{U_\circ}(P_\circ, T_\circ)$ and $\overline{S_\circ}(P_\circ, T_\circ)$.

Derive expressions for the state functions $\overline{U}(P,T)$, $\overline{U}(V,T)$, $\overline{U}(P,V)$ and $\overline{S}(P,T)$, $\overline{S}(V,T)$, $\overline{S}(P,V)$.

Exercise 4.2

The molar heat capacity of solid aluminum is a weak function of temperature
$\overline{C_p} = 20.7 + 12.4 \times 10^{-3} T \left(\frac{\text{joule}}{\text{degree mole}}\right)$ for $300\text{K} < T < 900\text{K}$.

Suppose c grams of aluminum at temperature $T_c = 600(1 - \frac{\theta}{2})$ (kelvin) are put in thermal contact with h grams of aluminum at $T_h = 600(1 + \frac{\theta}{2})$ (kelvin).

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

(b) Plot the change in total entropy per mole of aluminum as a function of θ for values of c/h = (1/16, 1/8, 1/4, 1/2, 1).

Hints: Regard the two masses of aluminum together as comprising an isolated system. Work out an algebraic expression for the first part—using a program like Mathematica or Matlab on Athena will make life much much easier. Don't try to calculate and write out an expression for the second part—it is too messy. Find a team member that knows how to plot numbers and make sure that the plot that he or she produces makes sense.