MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Thermodynamics of Materials

3.00 Fall 2002

W. Craig Carter
Department of Materials Science and Engineering
Massachusetts Institute of Technology
77 Massachusetts Ave.
Cambridge, MA 02139

Problem Set 3: Due Mon. Sept. 30, Before 5PM in in 13-5114

Exercise 3.1

(a) Consider an adiabatically enclosed room of constant volume ($4 \times 6 \times 3\text{m}^3$) that contains an ideal diatomic gas ($\overline{C_P} = \frac{7}{2}R$) initially at 1 atm.

Calculate the minimum amount of work that must be passed into the room to heat it from 10°C to 25°C.

(b) Consider a typical enclosed room in a house that is very well thermally insulated with constant volume ($4 \times 6 \times 3\text{m}^3$) that contains an ideal diatomic gas ($\overline{C_P} = \frac{7}{2}R$) initially at 1 atm.

Calculate the minimum amount of work that must be passed into the room to heat it from 10°C to 25°C.

Exercise 3.2

There are four state variables for an arbitrary pure gas: total moles of gas molecules, pressure, volume, and temperature.

How many independent state variables exist for a mole of an ideal gas?

Using different combinations of independent variables, write as many unique (but numerically equivalent) expressions for the molar internal energy of an ideal gas as possible.

Exercise 3.3

Suppose that, in a desperate attempt to lower the temperature in your *adiabatically enclosed* dorm room, you prop open the door of your refrigerator. Your refrigerator operates at 110 volts and draws a constant 30 amperes.

Using the axes below, draw two *schematic* curves of the temperature in your adiabatically enclosed room as a function of time. For one curve, plot the temperature versus time for the case that the refrigerator door is kept closed; for the other curve, plot the temperature versus time for the case that the refrigerator door is kept open. *A schematic plot is one that illustrates relevant physical aspects of the system, but need not be numerically quantitative.*

Illustrate or annotate any relevant characteristics of your curves—and be sure to indicate which curve corresponds to each case.

Exercise 3.4

Consider an isolated system consisting of a kilogram of lead and a kilogram of water illustrated below.

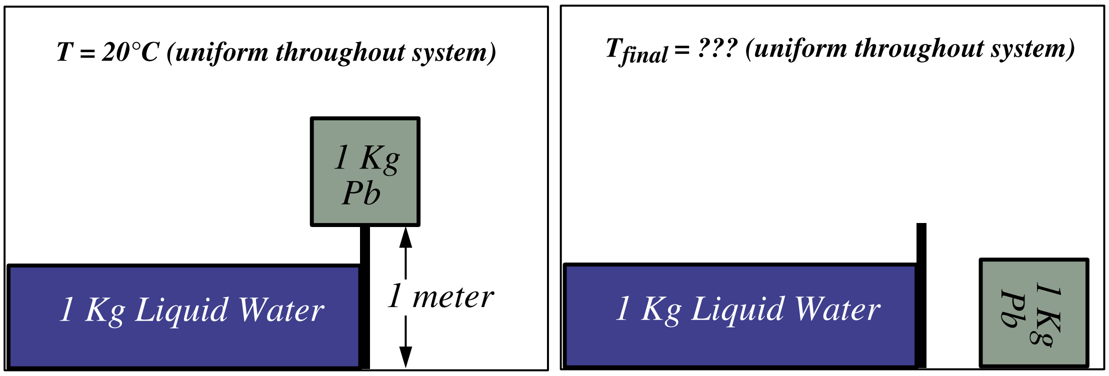

Figure 3-4-i: Isolated system illustrated before and after.

The heat capacity of 1 kilogram of Pb is given by C_{Pb}; the heat capacity of 1 kilogram of water is given by $C_{\mathrm{H_2O}}$; all other heat capacities in the isolated system can be neglected. C_{Pb} and $C_{\mathrm{H_2O}}$ may be considered independent of any constraints (e.g., constant pressure or constant volume) and to be independent of temperature.

(a) Derive an expression for the final temperature after a process leading to the figure on the right of the illustration.

(b) Would the temperature be larger or smaller if the block of lead had fallen to the left (i.e., into the water)?