Many cooking processes can be analyzed by accounting for energy flows. An example is the double boiler shown below.

The double boiler is used when a uniform temperature is required on the bottom surface of a cooking pot, in this case Can 1. Temperature uniformity is achieved by isolating the upper pot from the stove heating element through by interposing a pot of boiling water (Can 2).

Sketch the thermodynamic process on a P-v diagram and a T-v diagram for water contained in the lower pot as energy enters via heat transfer. The water always starts as a liquid at 1 bar and 25°C, and always ends up boiling. Initially, Can 2 is sealed and matter escapes as soon its pressure reaches 1.1 bar (the gap between the Can 1 and Can 2 rim opens when the water pressure reaches 1.1 bar).
The CO$_2$ in a paintball gun cartridge is originally at 50 bar and 0.001 m$^3$/kg. Repeated firings increase the specific volume to 0.05 m$^3$/kg, 0.0457 m$^3$/kg while the CO$_2$ pressure falls to 10 bar. Since firing is not in full automatic mode there is time for heat transfer from the surrounding air to occur. This results in an approximately constant temperature process.

- **What is the original state of the CO$_2$?**
- **What is the final state of the CO$_2$?**
- **Sketch the thermodynamic process the CO$_2$ follows during firing on a P-v and T-v diagram.**
Your parents certainly admonished you not to leave the outside door open when it was cold or hot outside. They claimed it ran up the home power bill. Let’s see if they were right.

The rate of infiltration through a standard residential exterior door (~2 m tall and ~0.91 m wide) can be computed from

$$\forall = \frac{1}{3} \cdot w \cdot h \cdot C_{dis} \sqrt{g \cdot h \cdot \left| \frac{T_{in} - T_{out}}{T_{out}} \right|}$$

where $\forall$ is the infiltration volume flow rate, in m$^3$/s, $w$ and $h$ are the door width and height, both in m, $g$ is the acceleration due to gravity, and $T_{in}$ and $T_{out}$ are the interior and exterior temperatures, in K. Assume $C_{dis}$ is 0.6.

- **Assume a door open time of 5 s, along with interior and exterior temperatures of 22 and 5 C respectively and compute the volume of air infiltration.** Report your answer in m$^3$.
- **Next, assume the 5 C air must be heated to 22 C by the residential heating system and compute the energy required to do so.** Report your answer in kJ.
- **For a worst case scenario, assume that the residential heating system is direct electrical and that the local electricity cost is $0.1026/kW-hr to compute the energy cost in $.**
- **Assume a total of three trips (in or out) each day, for eight months of the year to determine the annual energy cost.** Were your parents right?