AOSC 431-Atmospheric Physics and Thermodynamics, Fall 2016, Dr. Kleist
Homework #3 – DUE: THURSDAY 13 OCTOBER 2016 (5 PM)
All work needs to be shown for full credit.

1. [10 points] A kitchen oven with interior volume V of 0.15 m^3 is preheated from an initial temperature T_0 of 20 ^oC to a baking temperature T_1 of 220 ^oC (~425 ^oF). The initial pressure p_0 inside the oven equals the outside pressure of 1000 mb.
    a. If the oven is sealed (isochoric process), how much heat is added to the air in the oven?
    b. Let's instead assume that the oven is not sealed (not good!) and that some of the air can leak out as the air expands from heating to maintain constant pressure (isobaric process). Assume that the leakage is one way. How much total heat is added to the air (including that which leaks out). You may assume that the temperature inside of the oven is uniform at any point and the air leaking out of the oven has this temperature. You will need to set up and integrate a differential equation to solve.

2. [5 points] An isobaric layer (1000 mb to 500 mb) is subject to a heat source having a magnitude of 5.0×10^6 J m^{-2}. Assuming that the atmosphere is at rest (apart from slight vertical motions associated with expansion from heating), calculate the resultant increase in the mean temperature and thickness of the layer. You may ignore the effects of humidity in computing the thickness.

3. [5 points] A long haul airliner cruises at an altitude of approximately 12km, where the temperature may be -60 ^oC and pressure approximately 200 mb.
    a. Compute the potential temperature of the air at this altitude and temperature.
    b. Cabin pressure is typically maintained at about 750 mb. When the outside air is compressed adiabatically to the cabin pressure, compute the air temperature (in Celcius) that would result without additional influence or corrective action.

4. [5 points] The Martian atmosphere is mainly composed of carbon dioxide, and its gravitational constant is about 38% of that of Earth. Calculate the dry adiabatic lapse rate for Mars. You will need to compute a heat capacity consistent with the dry gas constant for the Martian atmosphere.

5. [5 points] 5000J of heat are added to 5kg of some unknown substance. It is observed that the temperature increases by 6K while the pressure remains unchanged. What is the heat capacity at constant pressure of the substance?

6. [10 points] A parcel of dry air is initially at a pressure of 950 mb and has a temperature of 15 oC. If the parcel rises (dry) adiabatically to a pressure of 850 mb, compute:
    a. Initial specific volume at 950 mb.
    b. Final temperature at 850 mb (using general form of Poisson's equation).
    c. Final specific volume at 850 mb.
    d. Work per unit area done by the parcel during this process.
    e. Potential temperature of parcel at 850 mb.
    f. Change in enthalpy per unit mass that occurred during process.
    g. Change in internal energy per unit mass that occurred during process.