Meteo 300 -- Introduction to Atmospheric Sciences

Problem Set #2

assigned: 29 January 2001

due: 2 February 2001

Do as much as you can by yourself before you work together.

1. Consider two air parcels, one that rises adiabatically and one that rises isothermally. Assume that for both parcels that they start with a pressure of 1000 hPa, temperarture of 300 K, and volume of 1000 m^3. (For adiabatic ascent, the relations among p, T, and V are: pV^{γ} = constant; $Tp^{(1-\gamma)/\gamma}$= constant; $TV^{(\gamma -1)}$ = constant, where $\gamma = c_p/c_v = 1.4$)
   a. What are the volume and temperature if the parcel rises to p=500 hP adiabatically?
   b. What are the volume and temperature if the parcel rises to p=500 hP isothermally?
   c. Give a physical reason for the difference between the two cases.
2. How much work is done by the parcel during its isothermal ascent from 1000 hPa to 500 hPa? (Recall that the total work is the integral of pdV.)

3. How much work is done by the parcel during its adiabatic ascent from 1000 hPa to 500 hPa? (Recall that the total work is the integral of pdV.)

4. Consider two air parcels at the same pressure but different temperatures and volumes. Parcel 1 has T=300 K and V = 2000 m^3, while parcel 2 has T = 270 K and V = 8000 m^3. Assume the pressure is 960 hPa.

   a. What is the density of each air parcel?
      Assume that the two air parcels mix together completely.
   b. What is the density of the new air parcel?
   c. What is the temperature of the new air parcel?

5. The First Law of Thermodynamics is du = dq – dw. If the volume doesn't change, (no working), then what is the rise in temperature for an air parcel with a volume of 1000 m^3, pressure of 1000 hPa, and temperature of 290 K if $1x10^5$ J of energy is added to the air parcel? What is the pressure rise?

6. What is the rise in temperature for this air parcel if the volume is allowed to change at constant pressure? What is the change in enthalpy?

7. Consider a shallow layer of cold air 200 m deep (like the nighttime Planetary Boundary Layer). Assume a pressure of 1000 hPa and an initial T of 280 K for the entire layer. If the sun shines on this layer with a solar flux of 500 W m^{-2}, heats the surface, and half of that energy goes into the atmosphere, what is the temperature of the air layer in two hours? (Assume constant pressure.)

8. For an air parcel with a potential temperature of 380 K at 21,000 ft altitude, what is the temperature? You will need to relate altitude to pressure, using the hydrostatic equation.