Atmospheric Thermodynamics **Meteo 3510**

Exercise 4 **Due: Thursday, February 7, 2008**

These problems deal with thermodynamic processes and the first law of thermodynamics.

Problem 1:

Write a MATLAB program to calculate the dry adiabats of an $\alpha, -p$ diagram for air for potential temperatures of 200 K, 300 K, and 400 K. Add these to the plot you made for **Problem 4** of **Exercise 1**. Clearly label the adiabats (either using the MATLAB command `legend`, or neatly by hand).

Problem 2:

(a) Consider a dry air parcel at -10°C and 40 kPa (400 mb) that descends adiabatically to 100 kPa (1000 mb). What is its temperature there? What is its potential temperature?

(b) Consider a dry air parcel at 10°C and 85 kPa (850 mb) that ascends adiabatically to 50 kPa (500 mb). What is its temperature there? If it then descends to 100 kPa (1000 mb), what is its temperature there? What is its potential temperature?

Problem 3:

Calculate the changes in specific internal energy, Δu, and specific enthalpy, Δb, of dry air for the following processes:

(a) Isothermal expansion from α =0.9 m^3 kg^{-1} to 0.95 m^3 kg^{-1}.
(b) Isobaric heating from -10°C to +10°C.
(c) Isosteric cooling from 0°C to -10°C.
(d) Adiabatic compression from α =0.9 m^3 kg^{-1} to 0.85 m^3 kg^{-1}. The initial pressure is 100 kPa (1000 mb).

Answers: **(b)** Δu = 14.3 kJ kg^{-1}, Δb = 20.1 kJ kg^{-1}; **(c)** Δu = −7.2 kJ kg^{-1}, Δb = −10.0 kJ kg^{-1}; **(d)** Δu = 5.20 kJ kg^{-1}, Δb = 7.20 kJ kg^{-1}.

Problem 4:

For each of the following cases, *sketch the process described on an α, p diagram and graphically represent the work done by the parcel.* Then calculate the work done per unit mass by the air parcel (w) and the energy gained by heating per unit mass by the parcel (h).

(a) An air parcel expands isothermally from α =1 m^3 kg^{-1} to 2 m^3 kg^{-1} at T = 300 K.
(b) An air parcel expands isobarically from α =1 m^3 kg^{-1} to 2 m^3 kg^{-1} at p = 50 kPa (500 mb).
(c) An air parcel warms isosterically from 280 K to 300 K at α =1 m^3 kg^{-1}.
(d) An air parcel expands adiabatically from α =1 m^3 kg^{-1} to 2 m^3 kg^{-1} at θ = 300 K.