

ATMOSPHERIC SCIENCES 340
WINTER QUARTER 2009
PROBLEM SET 4
DUE FRIDAY FEBRUARY 27 AT 9:30 AM

- 1) An air parcel containing cloudy air, initially at $T = 0^{\circ}\text{C}$ and $p = 800$ hPa, is lifted to 700 hPa. It then mixes with an equal amount of ambient air that has $T = -15^{\circ}\text{C}$ and a mixing ratio of 0.1 g kg^{-1} . Determine the temperature and mixing ratio of the new air parcel immediately after it has mixed (before any additional latent heating or cooling occurs). If enough water is now evaporated from the cloud droplets within the air parcel to again bring the air to saturation, what is the final temperature of the parcel? How much liquid water (expressed as kg liquid water per kg dry air) had to be evaporated?
- 2) An air parcel at $p = 1000$ hPa and $T = 20^{\circ}\text{C}$ has a wet-bulb temperature of 15°C . What is the dewpoint and mixing ratio of the air? If this air is lifted until all of the moisture condenses and falls out, and then the parcel is brought back down to 1000 hPa, what is the final temperature of the air?
- 3) An air parcel at 900 hPa has a temperature of 16°C and a mixing ratio of 9 g kg^{-1} . What is the wet-bulb potential temperature of the air? The air is lifted to the 600 hPa level by passing over a mountain, and 75% of the water vapor that is condensed out by the ascent is removed by precipitation. Determine the temperature, potential temperature, mixing ratio, and wet-bulb temperature of the air parcel after it has descended to the 900 hPa level on the other side of the mountain.
- 4) An air parcel at 850 hPa has a temperature of 27.5°C and a dewpoint of 10°C . What is its mixing ratio? At what pressure is its LCL? What is its potential temperature? What is its equivalent potential temperature? What is its wet-bulb temperature? What is its wet-bulb potential temperature?
- 5) An air parcel at 650 hPa, with $T = 7^{\circ}\text{C}$ and $T_d = -22^{\circ}\text{C}$, descends adiabatically to 900 hPa, and during its descent, rain falling through the parcel evaporates, so that w increases by 4 g kg^{-1} . What is the T of the parcel? What are its θ_w and θ_e ?
- 6) Plot the following on a skew $T - \log p$ diagram and answer questions a through e (continued on reverse):

Temperature follows the $T = 300$ K dry adiabat from 1000 to 900 hPa; then follows a straight line to the point $p = 830$ hPa, $T = 20^{\circ}\text{C}$; then to the point $p = 550$ hPa, $T = -10^{\circ}\text{C}$; then to the point $p = 250$ hPa, $T = -55^{\circ}\text{C}$; then isothermal above that point. Dewpoint follows the 12 g kg^{-1} saturation mixing ratio line from 1000 to 900 hPa; then follows a straight line to the point $p = 830$ hPa, $T = -2^{\circ}\text{C}$; then to the point $p = 150$ hPa, $T = -100^{\circ}\text{C}$.

- a) For each of the following layers, characterize the lapse rate as either absolutely unstable, dry neutral (or dry adiabatic), conditionally unstable, moist neutral (or moist adiabatic), or absolutely stable. Also indicate if a layer is an inversion.

1000-900 hPa

900-830 hPa

830-550 hPa

550-475 hPa

475-400 hPa

400-250 hPa

Above the 250 hPa

- b) Prove that the layer from 900 to 830 hPa is convectively unstable.
- c) Now draw the temperature profile of a surface air parcel lifted up to 150 hPa. What is the LCL of the parcel? What is the LFC of the parcel? What is the EL of the parcel?
- d) Indicate with hatching the CIN and CAPE for this parcel on the diagram.
- e) Estimate CAPE. Ignore T_v effect. Assume that the reference air parcel in the layer between the LFC and EL is on average 5°C warmer than environmental air at the same level.