AOSC 431-Atmospheric Physics and Thermodynamics, Fall 2016, Dr. Kleist
Homework #4 – DUE: TUESDAY 25 OCTOBER 2016 (5 PM)
All work needs to be shown for full credit. 50 points

1. [5 points] A 0.5 m^3 volume of air at 20 °C and a relative humidity of 60% is compressed isothermally to a volume of 0.1 m^3. Calculate the mass of water condensed. The saturation vapor pressure of water at 20 °C is 23 hPa. (Density of air at 0 °C and 1000 hPa is 1.28 kg m^{-3}.)

2. [5 points] The human body perspires in an effort to cool down via evaporation. How much liquid water (as a percentage of the mass of the person) must evaporate to lower the temperature of the person by 3 ^oC? Assume that the latent heat of evaporation of water (L) is 2.5 x 10^6 J kg^{-1} and the specific heat of the human body is 4.2 x 10^3 J K^{-1} kg^{-1}. Start with the following form of the first law:
$$\delta q = -L dw_s = c_{person} dT$$

3. [5 points] A parcel of moist air has a total pressure of 975 hPa and a temperature of 20 °C. If the mixing ratio is 9.0 g kg^{-1}:
   a. What is the virtual temperature for the parcel?
   b. Estimate the water vapor pressure.

4. [5 points] Using an approximate form of the Clausius-Clapeyron equation (describe which one you used), calculate the saturation vapor pressure at
   a. -10 ^oC
   b. 10 ^oC
   c. 30 ^oC

5. [10 points] On a winter day, the outside air has a temperature of -10 ^oC and a relative humidity of 75%.
   a. If outside air is brought inside and heated to room temperature (20 ^oC) without adding additional moisture, what is the new relative humidity?
   b. If the room volume is 50 m^3, what mass of water must be added to the air by a humidifier to raise the relative humidity to 50%?
   c. How much heating energy is needed in order to accomplish (a) and (b)? You may assume that you are near sea level. How much heat is associated with the evaporation to raise the RH in part (b) [i.e. Lv*mv].

6. [5 points] During summer, daytime temperatures are typically around 30 ^oC for both the eastern U.S. as well as the high deserts over the western U.S. In the first case (east), typical relative humidity is observed to be as high as 75% while in the west it may be as low as 10%.
   a. Compute the corresponding dew points for the east and west given the above relative humidity and temperatures.
   b. Find the expected altitude of the base of any convective clouds (in meters) that may develop from surface heating.

7. [15 points] Use the following sounding information for parts a-g:

pressure (hPa)	temperature (ºC)	dew point (ºC)
1014	8.6	-1.4
950	4.1	-5.0
925	2.0	-6.0
882	-1.2	-7.8
850	-3.5	-9.5
800	-7.5	-13.5
740	-12.1	-13.1
700	-9.7	-33.7
633	-15	-38.9
551	-20.9	-45.9
500	-24.5	-51.5

a. Plot the above sounding on a Skew *T* ln *p* diagram (provided on next page or download from class website).
b. Find the mixing ratio, relative humidity, wet-bulb temperature, potential temperature, equivalent potential temperature, and wet-bulb potential temperature at the surface using the Skew T.
c. Find the mixing ratio, relative humidity, wet-bulb temperature, potential temperature, equivalent potential temperature, and wet-bulb potential temperature at 700 hPa using the Skew T.
d. Find the mixing ratio, relative humidity, wet-bulb temperature, potential temperature, equivalent potential temperature, and wet-bulb potential temperature at 500 hPa using the Skew T.
e. Where is the lifting condensation level?
f. Calculate potential temperature at the surface, 700 hPa, and 500 hPa.
g. Calculate the equivalent potential temperature at the surface, 700 hPa, and 500 hPa.

Skew T – ln p Chart