ATSC5010

Homework #3 (Oct 10)
Due beginning of class October 18

1. The Armstrong Limit is the altitude that is often cited as the altitude at which 'human blood will boil within the body'. While this is not *exactly* true…it is true that at this altitude, if a human were able to survive without a pressure suit, normal human secretions such as saliva on one's tongue would begin to boil. Calculate this altitude. (Use C-C relationship for $e_s = f(T)$)

2. Consider a parcel with temperature, T_0=20 C, P_0=1000 mb. The parcel is lifted adiabatically to 800 mb, at which the parcel just becomes saturated. Do the following:
   a. Derive an equation that describes the initial saturation vapor pressure of the parcel as a function of: T_{tr} = 273.16 K, e_{tr} = 611 Pa, L_v, R_v, and initial temperature, T_0 (assume Lv and Rv are constant with T).
   b. What is the final temperature of the parcel (in C)?
   c. What is the final saturation mixing ratio (in g/kg)?
   d. What is the <u>initial</u> *actual* mixing ratio (in g/kg)?

For the following problems, unless otherwise noted, use the following relationship from Bolton (1980; MWR) to relate saturation vapor pressure and temperature:

$$e_{ws} = 6.112 * exp\left\{\frac{17.67*T}{T+243.5}\right\},$$

where T is temperature in degC and e_{ws} is in mb.
Also, assume constant latent heat of vaporization (L_{lv}) and constant latent heat of sublimation (L_{iv}) at 0 C given in Table 4.2 (pg 110) of Curry and Webster.

3. Now, consider the parcel in problem #2. At 800 mb, the parcel has a temperature of T_{800} = 1.9 C and it is saturated. Allow the parcel to continue its ascent to 550 mb. Assume that all condensed water is removed immediately from the parcel and further assume there is no deposition or freezing. Calculate the following:
   a. The final temperature of the parcel (at 550 mb) – you will need to solve this numerically, use any method you prefer (idl guess and minimize, equation solver, etc).
   b. The amount of water vapor condensed during the ascent.
   c. Allow the parcel to descend back to its original level. What is the new temperature at dewpoint of the parcel at 900 mb? How does this new temperature and dewpoint compare to the original? Describe a real-world example of this overall process.

4. Consider a closed parcel at state A: 800 mb with an initial temperature of 15 C and initial dewpoint of 8 C. The parcel then undergoes isobaric cooling to state B (process 1) at which point its new temperature is 8 C. The parcel undergoes further isobaric cooling to state C (process 2) where its final temperature is 1 C. Complete the following table:

Variable	**State A**	**State B**	**State C**
T	15 C	15 C	1 C
T_D	8 C		
w_v			
w_l			
w_t			

   a. Assuming dry air only (ignore the contribution from water vapor and liquid water), What is the total change in heat for the parcel to go from State A to State C (how much heating/cooling has occurred)?
   b. Compare the heating/cooling for process 1 (A→B) and process 2 (B→C). Which is greater? By how much? Why?
   c. In (a), if you had considered the contribution from water vapor and liquid water would the total heat change been more, less or the same? Explain.
   d. Sketch the above processes on a P-T diagram. Use arrows to indicate direction. Label vapor pressures, saturation vapor pressures, temperatures and dew points for all states.

5. You use a sling-psychrometer to measure wet-bulb and dry-bulb temperatures. Assume the surface pressure is 900 mb and your measurements reveal a temperature (dry-bulb) of 20 C and wet-bulb temperature of 15 C.
   a. What is the dewpoint temperature?
   b. If you take another measurement, 2 hours later and the wet-bulb remains at 15 C, but the dry-bulb has increased to 25 C, has the dewpoint temperature changed? If so, did it increase or decrease? Explain.

6. Assume you have a parcel with an initial temperature T_i=-20 degC, pressure of 1000 mb, and liquid water mixing ratio, w_l = 1.0 g/kg. Further assume that the parcel is initially at a meta-stable equilibrium---saturated with respect to water. If all of the liquid were to freeze, the parcel would re-adjust to a new equilibrium---saturation with respect to ice. (NOTE- for esi, use C-C with constant Liv at 0C). Compute:
   a. The final temperature of the parcel,
   b. The final ice water mixing ratio (w_i).
   c. Illustrate the process on P-T diagram, showing the initial parcel (T, T_{dew}, and T_{frost}) and the final parcel (T, T_{dew}, and T_{frost}).

7. Consider two 1-kg parcels at 1000 mb. Parcel A has a temperature of 10 degC and a dew point of 5 degC. Parcel B is has a temperature of 20 degC and a dew point of 14.5 degC. The parcels mix isenthalpically.
   a. What is the temperature of the final, mixed parcel?
   b. What is the RH of each *individual* parcel?
   c. What is the RH of the final, mixed parcel? (Note—this can be determined without any approximations)
   d. How does the RH of the mixed parcels compare to the RH of each of the individual parcels. Does this make sense? Explain.