ATSC5010

Homework 3b (Oct 24)
Additional problems following homework assignment 3

For all problems that require calculation of saturation vapor pressure (or actual vapor pressure) as function of temperature (or dewpoint) use the following Bolton Equation:

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

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.

1. A parcel at 1000 mb has a temperature of 30 C and a dewpoint of 5 C.
    a. Write out the equation that you need to solve to determine the wet-bulb temperature.
    b. Solve this equation **numerically**. In class we learned about the bisection method. That is a simple way to find a numerical solution. You may *compare* your answer to that from a thermodynamic diagram, but DO NOT USE a thermodynamic diagram to get your answer for wet-bulb.

2. A parcel begins at -15 C and is saturated with respect to liquid water. The parcel also contains 3 g/kg of liquid. The liquid freezes and the parcel re-adjusts to a new equilibrium with respect to ice.
    a. In class we learned how we can look 3 steps of this process individually. For each 'step' we can calculate a change in enthalpy. Write out an equation for each of the 3 steps – indicate values if they are known (such as latent heats, specific heat capacities, initial temperature, etc; indicate which values, like final temperature, are not known {and therefore must be calculated}).
        i. Step1 – change in enthalpy due to freezing of liquid.
        ii. Step 2 – change in enthalpy due to temperature change of parcel.
        iii. Step 3 – change in enthalpy due to sublimation/deposition of ice/vapor as parcel readjusts its equilibrium from saturation with respect to liquid at initial temperature to satutration with respect to ice at its final temperature.
    b. NOW….combine the 3 equations into one equations (hint-this process is isenthalpic, ie the enthalpy does not change!)
    c. SOLVE the equation (THIS WILL NEED TO BE ACCOMPLISHED NUMERICALLY) to find the final temerpature.
    d. NOW, take a step back…..what was the initial vapor mixing ratio? What is the final vapor mixing ratio? Has it changed, and if so where did it go to (or come from)?
    e. We began with 3 g/kg of condensed water in the form of liquid and NO ICE. We will end with no liquid and some ice. How much ice is in the final parcel?

3. Consider two 1 kg parcels. Both have an RH of 95%. One parcel has a temperature of 0 C, the other has a temperature of 25 C. The parcels mix isenthalpically.
    a. What is the *intermediate temperature* of the mixed parcel?
    b. What is *intermediate RH* of the mixed parcel?
    c. Will this parcel remain in this condition? Ie is it in a 'stable' equilibrium?
    d. If your answer to (c) is no, describe in words what will happen?
    e. Now use your math and programming skills (yes….you will need to solve this numerically) to compute the final temperature of the parcel.
    f. How much water has condensed in the process?