This exercise considers the evolution of the chemical composition of water as it travels from rain into groundwater. We’ll just focus on solution chemistry here; in later assignments we’ll look and interactions with rocks and so forth. Assume 25 degrees C (standard temp) and use data from Appendix D in text.

1. Assume that rainwater is distilled water in equilibrium with the atmosphere at $P_{CO_2} = 10^{-3.5}$ atm. List the pH and the concentration of all chemical species present (i.e., $H^+$, $OH^-$ and the various carbonate species.) Recall that you can get the carbonic acid concentration $[H_2CO_3]$ from the $P_{CO_2}$ by multiplying $P_{CO_2}$ by Henry’s Law constant of $10^{-1.5}$ M/atm. With that value you can get the other carbonate species and the pH. As in the HAc problem in P-set 1, you can assume that all of the $[H^+]$ comes from the dissociation of $H_2CO_3$, with the formation of an equal amount of $HCO_3^-$.  

2. When the rain penetrates the soil it comes into equilibrium with soil vapor $P_{CO_2}$ which, due to root and microbe respiration, has a higher $P_{CO_2} = 10^{-1.5}$ atm. Assume no other chemical reactions occur in the soil zone. List the pH and the concentration of all chemical species present.

3. A small amount of $Ca^{2+}$ dissolves out of the soil to $Ca_T = 10^{-3.0}$ M. Determine the speciation of $Ca$ in this water. Verify that $CaCO_3$ does not precipitate out.