Problem set #2 Fall 2014

**GEOL1370: Environmental Geochemistry**

**Rainwater chemistry and weathering (Due Tuesday, 9/30)**

1. Tabulate all the results of pH and alkalinity measurements of various waters collected during our field trip. Please include site information (put on the sampling sites on a map).
   1. Can you identify certain trends in the data? Please compare the pH and alkalinity in different waters, and explain the causes for the variability.
   2. What is the pH of neutrality for the pure water at 25oC?
   3. What is the alkalinity of the pure water (i.e., only H2O, H+, and OH- in the water with no dissolved ions)?
   4. How many of your samples have pH lower than the pH of neutrality? Demonstrate that these waters with lower pH than that pure water have higher [H+] than the pure water. Do these waters also have higher alkalinity than the pure water? How could this happen (i.e., why do samples with higher [H+] also have higher alkalinity)?
   5. Suppose we could not complete our alkalinity measurements on site and had to bring our samples home. After a couple of days 20 % of the CO2 dissolved in the water samples have escaped to the atmosphere (the water was originally super-saturated with CO2), although no precipitation has formed. Can you still use this water to measure the alkalinity and pH? Explain why?
   6. For the same situation in question (d), if some carbonate has precipitated from the water after a couple of days, can you still use the water to accurately measure the alkalinity?
2. a. Describe the main differences in major ion concentrations between continental rain and coastal rain and explain why these differences exist.
3. The average ionic composition of precipitation at Menlo Park, California, is given in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Concentration (mg/L) | Species | Concentration (mg/L) |
| Cl- | 3.43 | Mg2+ | 0.37 |
| Na+ | 2.00 | Ca2+ | 0.79 |
| SO42- | 1.39 | K+ | 0.25 |

1. Relative to average ocean-derived rainwater, calculate the excess or deficiency of each of these species. Assume that all Cl- is from a marine source.
2. Given the calculated excesses and deficiencies, what is the main source of each of the species in the rainwater?
3. a. Acidity in rain is only produced when oxidized sulfur and nitrogen species (e.g., SO2 and NO2) dissolve in the rain water. However, formation of rain water from sea water containing significant amounts of SO42- does not change the pH of the rain. Explain why.
4. Why are natural waters (e.g., lakes) in some regions less affected by acid rain than those in other regions?
5. Give the general formula for calculating alkalinity in natural waters. Explain why alkalinity determines the ability of the water to neutralize acid input.
6. Following the example given in lecture, calculate the pH of the rain on Earth during the Cretaceous Period, ~100 million years ago. Assume that the atmospheric CO2 concentration was 7 times greater than the current level.
7. Precipitation at Katherine, Northern Territory, Australia, has SO42- = 0.19 mg/L and NO3- = 0.25 mg/L. Calculate the pH of Katherine precipitation assuming that all sulfate and nitrate are derived from fossil fuel combustion. The measured pH is 4.74. Compare the computed and measured pH values.
8. Explain the GOLDICH’S stability series (Why some minerals are weathered more rapidly than others). Two sediments of similar age have different mineral compositions, one contain primarily quartz and some clay minerals, but the other contain significant amounts of feldspars and mica, in addition to quartz and clays, what can you say about the weathering history of the two sediments?
9. a) Draw a simplified diagram of typical soil horizons in well-developed soils from a granite bedrock, explain the major characteristics of the horizons and their origins; b) In order to reconstruct the process of chemical weathering, it is necessary to select a substance in the source rock and resultant soil that can be considered relatively inert to weathering, with which concentrations of other soil constituents can be compared. Al2O3 and TiO2 have been used for such purposes. Once an inert “trace” has been selected, how can such an analysis of weathering be performed?
10. Explain the major mineralogical differences between the weathering products kaolinite, bauxite and smectite. What are the natural conditions that favor the formation of these clay minerals from igneous rocks? Explain the potential hazards of construction on soils containing high amounts of smectite.
11. Tin mining has been carried out in Cornwall, England, for many years. The tin ore normally occurs together with iron pyrite (FeS2), arsenopyrite (FeAsS) and sulfides of a number of metals such as cadmium and zinc. Following the closure of a tin mine, the pumps were removed and the mine shafts filled with water. The water flows out of the mine into streams which eventually drain into the estuary of the River Fal. In the context of this environmental disaster:

(i). Explain the chemistry behind the following: (a) the water coming out of the mine is highly acidic; (b) the stream and estuary waters contain large quantities of orange-brown sediment; (c) the levels of dissolved cadmium in both the mine drainage and the estuary are high.

(ii). Suggest some remedial actions to minimize the environmental impact of this discharge.