2.2 Acid mine drainage

Problem 2.2 *The weathering of iron sulphide minerals produces acidified water, leading to major environmental problems from abandoned metal and coal mines. If the water is then diluted or neutralised such that the pH is raised sufficiently, a sludge is precipitated, consisting of $Fe(OH)_3$, which can discolour water systems and affect plant and animal life.*
The redox reaction in this acid mine drainage can be summarised by the equation (as yet unbalanced): FeS_2 + oxygen + water → sludge + H_2SO_4

- *How many litres of water would be used up in a reaction with a cubic metre of pyrite and how much sulphuric acid is produced?*
- *If this acid finds its way into a lake, how could you predict whether the sludge is likely to be formed?*

- Assume that the acid completely dissociates. This isn't completely true, there is an equilibrium point (as we will see in a later problem).
- Pyrite has a density of 5.01 gcm^{-3}.
- The sludge forms at a pH greater than 3.
- Assume the lake contains a million cubic metres of water.

2.2.1 Notes

2.3 Problems

1. Balance the following chemical equations:
   - Oxidation of galena to anglesite: $PbS+\underline{2}O_2 \rightarrow PbSO_4$.
   - Oxidation of magnetite to hematite: $Fe_3O_4+O_2 \rightarrow Fe_2O_3$
   - Weathering of alkali feldspar to kaolinite:
     $\underset{\text{orthoclase}}{KAlSi_3O_8} + \underset{\text{groundwater}}{H^+ + H_2O} \rightarrow \underset{\text{kaolinite}}{Al_2Si_2O_5(OH)_4} + \underset{\text{groundwater}}{K^+ + Si(OH)_4}$
   - Thermal metamorphism of sandy dolomitic limestone (i):
     $\underset{\text{dolomite}}{CaMg(CO_3)_2} + \underset{\text{quartz}}{SiO_2} \rightarrow \underset{\text{diopside}}{CaMgSi_2O_6} + CO_2$
   - Thermal metamorphism of sandy dolomitic limestone (ii):
     $CaMg(CO_3)_2 + SiO_2 + H_2O \rightarrow \underset{\text{amphibole}}{Ca_2Mg_5Si_8O_{22}(OH)_2} + CaCO_3 + CO_2$
   - $\underset{\text{albite}}{NaAlSi_3O_8} + H_2O + CO_2 \rightarrow \underset{\text{kaolinite}}{Al_2Si_2O_5(OH)_4} + Na^+ + HCO_3^- + H_4SiO_4$
   - $\underset{\text{anorthite}}{CaAl_2Si_2O_8} + H_2CO_3 + H_2O \rightarrow \underset{\text{kaolinite}}{Al_2Si_2O_5(OH)_4} + Ca^{2+} + HCO_3^-$
2. The compositions of an unknown mineral has been analysed and the percentages by weight of its constituent elements are now known. They are:
   Cu 63.31%
   Fe 11.13%
   S 25.56%
   How can you work out what the chemical formula of this mineral is?
3. A more common way of analysing mineral compositions is as a combination of simpler compounds. For example, for silicates the oxygen is no longer given separately but as part of stable, neutral oxides with each cation in turn. Can you adjust your method and thus find what this is:
   CaO 37.35%
   Al_2O_3 22.64%
   SiO_2 40.02%
4. Write down a methodology of how to balance chemical equations.

2.4 Notes on problems

2.4.1 Homework and reading for next time

Background reading:

- Croft and Davison (2006, chapters on 'The exponential function', 'The logarithm function') OR 2.16,2.17,2.18,3.4,3.5 and 3.6 of the *Foundation Maths Support Pack*.

Do this weeks assessment on Blackboard:

- 'The exponential and the logarithm functions'.
- 'Acid mine drainage'.