GLS353 Geochemistry Practice Exercises Spring 2010
Try to think through how you would do these problems before consulting the hint page.
You have all learned enough material to answer these questions.

1. Andalusite, kyanite and sillimanite are all polymorphs (they have the same chemical formula but a different atomic structure…Al$_2$SiO$_5$).

Using your table of thermodynamic data at standard state, which phase is most stable at standard state conditions? Explain how you determined this.

2. Sketch the Al$_2$SiO$_5$ phase diagram with Pressure on the y-axis and Temperature on the x-axis. Include only the phases… andalusite, kyanite and sillimanite. Use Le Chatilier’s principle and the table of thermodynamic data to do this.

3. Portlandite (Ca(OH)$_2$) is the major mineral phase of most cements. Cement is used in wells, bridges, buildings and all sorts of materials. If Portlandite is altered to Calcite, there may be fundamental changes to the integrity of the structures made from cement. Is Portlandite stable in the presence of atmospheric CO$_2$(g)?

Consider the following reaction for this problem…

\[
\text{Ca(OH)}_2 (\text{portlandite}) + \text{CO}_2(g) = \text{CaCO}_3 (\text{calcite}) + \text{H}_2\text{O}
\]

4. Is there a temperature where Portlandite can be stable in the presence of Calcite and atmospheric CO$_2$ (consider temperatures between 25 and 350 degrees C)?

5. When observing mineral assemblages in altered volcanic rocks, it was noticed that some of the assemblages contain only anhydrite while others contain only gypsum. Sometimes they are found together in the same assemblage. When found together, the textures indicate that the gypsum seems to be replacing anhydrite. Can you explain some of the alteration history of the rock? (you may consider water to be a pure phase)…

\[
\text{CaSO}_4 (\text{anhydrite}) + \text{H}_2\text{O} = \text{CaSO}_4\cdot\text{H}_2\text{O} (\text{gypsum})
\]

6. Besides the two reactions written above, you can use the following reactions to calculate the standard state Enthalpy change, Gibb’s energy change, volume change and Entropy change…

\[
\text{Mg(OH)}_2 (\text{brucite}) + \text{CaCO}_3 (\text{calcite}) = \text{Ca(OH)}_2 (\text{portlandite}) + \text{MgCO}_3 (\text{magnesite})
\]
\[
\text{MnCO}_3 (\text{rhodochrosite}) + \text{SiO}_2 (\text{alpha quartz}) = \text{MnSiO}_3 (\text{rhodonite}) + \text{CO}_2(g)
\]
\[
2 \text{Al}_2\text{O}_3\cdot3\text{H}_2\text{O} (\text{gibbsite}) + 2 \text{SiO}_2 (\text{alpha quartz}) = \text{H}_2\text{O} + \text{Al}_2\text{Si}_2\text{O}_7\cdot2\text{H}_2\text{O} (\text{kaolinite})
\]