Chapter 4 Problems

1. Calculate the entropy of formation from the elements of anorthite ($CaAl_2Si_2O_8$). Combine this with the enthalpy of formation from the tables to calculate the Gibbs energy of anorthite. Compare with the value in the tables.

2. Calculate $\Delta_r H^\circ$ and $\Delta_r G^\circ$ for the reaction

$$\mathrm{NaAlSiO_4}(\textit{nepheline}) + 2\,\mathrm{SiO_2}(\textit{quartz}) = \mathrm{NaAlSi_3O_8}(\textit{low albite})$$

   at 25°C, 1 bar. Is the reaction endothermic or exothermic? Which way would the reaction go under standard conditions in the absence of kinetic barriers? What actually happens if you put quartz and nepheline together?

3. (a). Calculate the value of R in J mol^{-1} K^{-1} from the ideal gas equation ($PV = nRT$).
   (b). Use the dimensions (Appendix A) of energy and pressure to show that J bar^{-1} is a volume term, and calculate the conversion factor from J bar^{-1} to cm^3.

4. Is magnesite ($MgCO_3$) or nesquehonite more stable in water?

5. There are six naturally occurring oxides and hydroxides of aluminum listed in Appendix B, but only four of these have complete data (corundum, boehmite, diaspore, gibbsite). Note that the compositions of these phases differ only by the number of H_2O, so it is relatively easy to write reactions between them. By writing balanced reactions between these four phases, determine which one is most stable in water.

6. The origin of red-bed sandstones, in which the grains are coated with minute amounts of hematite, has long been controversial. A key question in the controversy is whether hematite is stable in water at low temperatures. Calculate whether goethite or hematite is stable in the presence of water at 25°C.

7. Calculate the heat input along the 600°C isotherm (which extends from 10,000 bars to 300 bars) and output along the 500°C isotherm, and the net heat in the Carnot cycle in Figure 4.11 In other words, calculate the area enclosed by the cycle.

8. The PV diagram for the Carnot cycle in Figure 4.11 is rather distorted because of the high pressure at one corner, which makes calculation of the area of the cycle very sensitive to the methods used. You can try this, but if you get agreement with the calculation in the previous question within 3% you are doing well.

   A more tractable cycle with which to compare the TS and PV representations is to use the 600°C isotherm between 100 and 55 bars, and the 500°C isotherm to complete the cycle. Coordinates of points along each of the four curves on the PV diagram can be found using program STEAM. Then

   - show that $q = -w$ for this H_2O Carnot cycle by calculating the areas in the TS and PV diagrams.

- Use the areas under the upper and lower isotherms on the TS diagram to verify the theoretical conclusion that

$$\frac{q_2}{q_1} = \frac{T_2}{T_1}$$

  where subscripts 2 and 1 refer to the high and low isotherms respectively
- find the "efficiency" of the cycle, w/q_2.

9. Write an equation for the surface in Figure 4.4.