12.109

Problem Set #1
Exchange reactions

The Fe-Mg olivine - melt exchange reaction and formation reactions provide useful tools for understanding the conditions of formation of basaltic magmas and for assessing significance of the composition of an olivine-bearing igneous rock. This problem set gives you some experience in using these exchange and formation reactions.

1) The equation for the Fe-Mg exchange reaction (K_D^{Fe-Mg}) is found in the course notes. Simplify the exchange reaction by substituting an ideal model for the activities of Fe and Mg in the olivine and the melt.

Thus: $a_{Fo}^{oliv} = X_{Fo}^{oliv}$ and $a_{MgO}^{liq} = X_{MgO}^{liq}$

Now use these expressions. the value of K_D^{Fe-Mg} and the relations: $X_{MgO} = 1 - X_{FeO}$ to develop expressions that allow you to predict X_{Fo}^{oliv} in terms of X_{MgO}^{liq} and X_{MgO}^{liq} in terms of X_{Fo}^{oliv}.

2) With your newly derived expression for olivine and melt Fe-Mg characteristics carry out the following tasks:

a) Predict the Mg# (this is a commonly used expression that is $= X_{MgO}^{liq}$) of a liquid in equilibrium with Fo_{90} olivine.

b). Calculate the Fo content of the liquidus olivine for a melt with an Mg# = 0.83.

3) Table 1 of Baker et al. gives the composition of a lava and the most Fo-rich olivine found in the lava.

a) Use the expressions given by Roeder and Emslie to calculate the crystallization temperature.**

b) We usually use this temperature as an estimate of the liquidus temperature for the rock. Why is this a good assumption?

c) What test should you always perform before you use the olivine and rock composition to calculate a crystallization temperature?

** Note that you will have to use the appropriate units for the Roeder and Emslie expressions. These are mole % of the oxides in mineral and melt. The compositions of the rock and olivine are given in wt. %. Transform to mole % by dividing by gram formula weight of each oxide and renormalizing to 100%.

References:

Baker et al. “Origin of compositional zonation (high-alumina basalt to basaltic andesite) in the Giant Crater lava field, Medicine Lake volcano, northern Calfornia.” *Journal of Geophysical Research* 96 (1991), 21819-21842.

Roeder, P. L., and R. F. Emslie. "Olivine-liquid equilibrium." *Contrib Mineral Petrol* 29 (1970): 275-289.