Thermodynamics and Isotopes in Geology, Problem 5

**Change of graphite into diamond at 25°C.**

Let’s use the equation we discussed in class to calculate the pressure at which graphite transforms into diamond at 25°C. Diamond is the high pressure form of carbon, as many of you already know.

**Step 1:**
In the space below, write a balanced reaction that shows the transformation of graphite into diamond:

**Step 2:**

<table>
<thead>
<tr>
<th>form</th>
<th>formula</th>
<th>ΔH° KJ/mol</th>
<th>ΔG° KJ/mol</th>
<th>S° J/mol/K</th>
<th>V° cm³/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>graphite</td>
<td>C</td>
<td>0</td>
<td>0</td>
<td>5.740</td>
<td>5.298</td>
</tr>
<tr>
<td>diamond</td>
<td>C</td>
<td>1.895</td>
<td>2.900</td>
<td>2.377</td>
<td>3.417</td>
</tr>
</tbody>
</table>

At 25°C and 1 bar, which form of carbon is stable? ________________

Why is this so? ______________________________________________

What happens to the *molar volume* when graphite transforms to diamond? ________________

What happens to the *entropy* when graphite transforms to diamond? ________________

Therefore, show on the graph below the “directions” to the graphite / diamond equilibrium line (from 25°C, 1 bar) and sketch in an approximate reaction boundary:
Step 3:
Using the Gibbs Free Energies listed, calculate the $\Delta G_{\text{rxn}}$. Express your final answer in J/mole.

Using the molar volumes listed, calculate the $\Delta V^0_{\text{rxn}}$. Express your answer first in cm$^3$ and then your final answer in J/bar.

Step 4:
Using the equation discussed in class, calculate the pressure (at 25°C) where graphite transforms to (is in equilibrium with) diamond. List your final answer in both bars and kilobars.

Step 5:
Calculate the $\Delta S^0_{\text{rxn}}$. Express your answer in J/mole/K.

Use $\Delta S^0_{\text{rxn}}$ and $\Delta V^0_{\text{rxn}}$ (calculated in Step 3) to determine the slope of the graphite / diamond transformation using the Clapeyron Equation.

How much higher would the equilibrium pressure be at 500°C? Show your calculation below:

Plot the graphite / diamond transformation boundary on the graph to the right. As noted, the pressure at the bottom of average continental crust (35 km thick) is about 10 kilobars.

Given your answers in Steps 4 and 5, is diamond ever stable in the Earth’s crust? _____