PHY411 Homework Set 12

1. [5 pts] Kittel-Kroemer, problem 10-1. Start from the Helmholtz free energy for the van der Waals gas.

2. [10 pts] Kittel-Kroemer, problem 10-4. The one-dimensional case is discussed on pages 285 and 286 of the book. You need to replace the one-dimensional partition function by a three-dimensional one for the solid.

3. [5 pts] Kittel-Kroemer, problem 10-5.

4. **Note:** Since we did not get far enough in the lecture, this problem will be moved to the next-week's set. You are free to turn it in if you want for this week, though.
   [10 pts] Kittel-Kroemer, problem 10-8. You should presumably review the Debye theory and the Planck radiation law in Chapter 4 of the book. Pay particular attention to the way in which the entropy for the gas of photons is obtained. Note that in this problem different quantities are considered per unit volume.

5. [10 pts] Use the Wolfram Alpha site (www.wolframalpha.com), a spreadsheet or a math package, such as Matlab or Mathematica, to produce isotherms for the van der Waals equation of state in reduced variables

$$\hat{p} = \frac{8\,\hat{\tau}}{3\,\hat{V} - 1} - \frac{3}{\hat{V}^2}\,.$$

   Plot an isotherm in the plane of $(\hat{p}, \hat{V})$ for $\hat{\tau} > 1$, for $\hat{\tau} = 1$ and three or more for $\hat{\tau} < 1$. For those subcritical isotherms carry out graphically a Maxwell construction. Note, that the volume axis must extend far enough in $\hat{V}$ to contain the construction in the figure at lower $\hat{\tau}$. Based on your findings sketch the envelope of the phase transition region in the $(\hat{p}, \hat{V})$ plane. All work, including a page or file with commands you used for plotting, should be enclosed with the homework you turn in.