Physics 410 -- Spring 2018

Homework #7, due Wednesday, March 21

1. [2] Kittel & Kroemer, Chapter 6, problem 6. Hint: Use the formula for the entropy of an ideal gas. Calculate the entropy for the type A and type B atoms separately, then add them.

2. [2] Kittel & Kroemer, Chapter 6, problem 5. Hint: For an ideal gas, does the internal energy U depend on the volume of the system?

3. [5] Kittel & Kroemer, Chapter 3, problem 6. For part (e), I recommend that you use Mathematica. First define the partition function Z as a function of the temperature. You will have to truncate the sum to a finite number of terms – say 10 or so. To find the energy you will need to use $U = \frac{\tau^2}{Z}\frac{\partial Z}{\partial \tau}$. I suggest you define a function that includes the τ^2 term and the derivative performed analytically inside the summation, like this:

   tsquaredtimesdZdt[*t*_]:= $\sum_{j=0}^{10}$(2j+1)* j*(j+1)*Exp[-j(j+1)/t]

   energy[t_]:=tsquaredtimesdZdt[t]/partitionfunction[t]
   Plot[energy[t],{t,0.1,3.0}]
   SpecificHeat[t_]:=energy'[t]
   Plot[SpecificHeat[t],{t,0.1,3.0}]

   Note that Mathematica may have trouble at $\tau=0$, so you may want to avoid plotting the specific heat right at $\tau=0$.

4. [3] Kittel & Kroemer, Chapter 6, problem 14.

5. [3] Kittel & Kroemer, Chapter 6, problem 15.
   In addition to doing the problem as stated in the text, answer the following questions:
   (b) From the value of γ given in the text, what is the value of C_V for air? Express your answer both in the dimensionless units used in the text, and in traditional units. In the latter case, express your answer for 1 mole of gas in J/K.
   (c) Given your answer to part (b), how many degrees of freedom are excited in air molecules (mostly N_2 and O_2) at room temperature? For a discussion of "degrees of freedom", see pages 77 and 78 of the text. What kinds of motions do those degrees of freedom correspond to? You may wish to consult figure 3.9.