Physics 3180 (Thermal Physics) Name ____________________
spring 2020

Problem Set 2

(due Wednesday, January 22, 10:30 am)

1. **For formal written solution:** Use the Interactive Molecular Dynamics simulation to measure the heat capacity of the simulated system (at constant volume) in both the gas and solid phases. The best way to do this is to use the data-gathering controls to record the system's temperature and total energy over a wide range of temperatures, using the Faster or Slower button to add or remove energy between measurements. Then copy and paste the data into a spreadsheet, plot energy as a function of temperature, and measure the slopes of different parts of the graph. The main pitfall is that you need to make sure the system has equilibrated, so the temperature fluctuations are minimal, before recording each data point. You can speed up this process somewhat by clicking the "Reset stats" button a few moments after adding or removing energy, so that non-equilibrium values aren't included in the subsequent averaging. Once you have your final graph, make a careful comparison of the heat capacity of this system to the predictions of the equipartition theorem, considering how many degrees of freedom it has in both the gas and solid phases. In your writup, be sure to describe your procedure as well as your results.

Additional problems:

2. An ideal gas is in a cylinder, initially at room temperature and occupying a volume V_i. My task is to push on the piston to compress the gas to a smaller volume, V_f. Being lazy, I wish to do as little work as possible. Should I compress the gas quickly, so there is no time for heat to flow out of the gas, or should I compress it slowly, so that the gas always remains essentially at room temperature? Explain carefully.

3. Problem 1.37, page 26. Assume an initial temperature of 300 K. Also please calculate the work required to compress the air during a single stroke, assuming an initial volume of one liter and an initial pressure of 1 atm.

4. Problem 1.45, page 31.

5. A beaker of water is initially at 30°C. The beaker is made of 100 g of aluminum (whose specific heat you can look up) and contains 180 g of water. (a) Suppose you add 100 g of ice, initially at 0°C, to the beaker. When the system again comes to equilibrium, what is the final temperature? If the temperature is 0°C, how much ice remains? (Assume that no heat escapes from the system.) (b) Repeat the analysis for the case where you add only 50 g of ice.

6. Problem 1.50, page 35.

7. Problem 2.2, page 51.

8. Problem 2.5, parts a, b, and c, page 55.