Phys 404
Spring 2011
Homework 2, CHAPTER 2
Due Thursday, February 10, 2011 @ 12:30 PM

Read Chapter 1 of Kittel and Kroemer.

1. Adiabatic process for an Ideal Gas. Starting from the first law of thermodynamics $\Delta U = Q + W$ and the fact that the internal energy of an ideal gas is $U = \frac{f}{2} N k_B T$, where f is the number of degrees of freedom of the particle, derive the result $PV^{\gamma} = constant$, with $\gamma = (f + 2)/f$, for an ideal gas undergoing an adiabatic process.

2. In the course of pumping up a bicycle tire, a liter of air at atmospheric pressure is compressed adiabatically to a pressure of 7 atm. (Air is mostly diatomic nitrogen and oxygen, with a number of degrees of freedom of $f = 5$.)

a) What is the final volume of the air after compression?

b) How much work is done in compressing the air?

c) If the temperature of the air is initially 300 K, what is the temperature after compression?

3. A fair coin is tossed 10 times, and the total number of heads and tails is counted.

a) What is the probability that precisely 5 heads and 5 tails will be the outcome?

b) What is the probability that precisely 6 heads and 4 tails will be the outcome?

c) The width of the probability distribution can be characterized by the root-mean squared deviation δN_{rms},

$$\delta N_{rms} \equiv \left\langle \left(\frac{1}{2} N - N_h \right)^2 \right\rangle^{1/2}$$

where N_h is the number of heads and N is the total number of tosses. Find δN_{rms} and $\delta N_{rms}/N$ for this problem.

4. A fair coin is tossed 10,000 times, and the total number of heads and tails is counted. HINT: Consider using the Gaussian approximation and make use of Appendix A of Kittel and Kroemer to do the Gaussian integrals.

a) What is the probability that precisely 5000 heads and 5000 tails will be the outcome?

b) What is the probability that precisely 6000 heads and 4000 tails will be the outcome?

c) Find δN_{rms} and $\delta N_{rms}/N$ for this problem.