Physics 7B, Fall 2007, Section 2, Instructor: Prof. Adrian Lee
First Midterm Examination, Tuesday October 2, 2007

Please do work in your bluebooks. You may use one double-sided 3.5" x 5" index card of notes. Test duration is 110 minutes.

(Giancoli Ch 20, problem 45)

1) Two samples of an ideal gas are initially at the same temperature and pressure; they are each compressed reversibly from a volume V to a volume V/2, one isothermally, the other adiabatically. (30 points total)

a) In which sample is the final pressure greater? (10 pts)

b) Determine the change in entropy of the gas for each process. (10 pts)

c) What is the entropy change of the environment for each process? (10 pts)

2) Three Independent Questions

a) **Heat Conduction.** A metal bar has a length L and has a uniform cross section. One end of the bar is held at 100°C and the other is placed in an ice-water mix. It takes 12 minutes for the bar to conduct enough heat to melt one kilogram of ice. How long would it take a uniform bar of the same metal and the same volume but of length 2L to melt one kilogram of ice? (10 pts)

b) **Radiative transfer.** On a hot day, the solar radiation incident upon a black surface is 1100 W/m^2. If the surface acts as a perfectly radiating body, what temperature does it come to? $\sigma = 5.67 \times 10^{-8}$ $W \cdot m^{-2} \cdot K^{-4}$ (10 pts)

c) **Kinetic theory of gases.** Is the total translational kinetic energy of all the molecules in a volume V of air at atmospheric pressure larger, smaller, or the same on a hot day as on a cold day? Give a brief explanation using simple equations. (10 pts)

3) The Stirling Cycle consists of (i) an isothermal expansion at $T = T_H$, (ii) a constant volume reduction in pressure at $V = V_a$, (iii) an isothermal compression at $T = T_L$, and finally (iv) a constant volume increase in pressure at $V = V_b$ to the starting point. In this problem, you will calculate the efficiency of this type of engine. Assume you know T_L, T_H, the two volumes (V_a and V_b), and that the specific heat is given by $C_V = 3/2R$ for the monatomic gas used in the engine.

a) Sketch the process in a P-V diagram. What is the heat and work during the two isothermal stages? (10 pts)

b) What is the heat and work during the two constant volume stages? (10 pts)

c) What is the net work, net heat, and the efficiency of the entire process? (10 pts) (for partial credit, express the efficiency in terms of net work and net heat without solving for the two expressions) (10 pts)