PHY 3513 Fall 1998 – Homework 2

Due at the start of class on Friday, September 11.

Answer all questions. Please explain your reasoning and show all working, write neatly and remember to include your name on the front page of your answers.

1. One mole of an ideal gas undergoes the following closed cycle, composed of three steps, starting from pressure P_0 and volume V_0:
(i) An isothermal increase in the volume to $2V_0$.
(ii) An adiabatic compression back to its original volume.
(iii) An isochoric return to the starting point of the cycle.

(a) Draw a P-V diagram (horizontal axis = V) showing the path followed by the system as it undergoes the thermodynamic cycle. Be sure to label the three steps (i, ii, or iii) and draw arrows to show the direction that the system moves on the diagram.

(b) Write down the volume, pressure and temperature of the system at the end of each of the three steps. Your answers should be expressed in terms of P_0, V_0, R (the gas constant) and γ (the exponent describing adiabatic processes).

(c) Calculate the work performed by the system during each step and hence the total work performed during the complete cycle.

(d) Evaluate the highest temperature reached during the cycle and the total work performed, given that $P_0 = 2.0 \times 10^5$ Pa and $V_0 = 1.0 \times 10^{-2}$ m^3. Assume $\gamma = 5/3$.

2. The temperature near the surface of the earth is 295 K. An oxygen molecule (mass $\approx 32\times$ that of a proton) has a kinetic energy three times the average translational kinetic energy and is moving straight up. Assuming that the molecule does not collide with any other and that the acceleration due to gravity remains equal to that at the earth's surface, how high does the molecule rise before coming to rest?

3. In 5.0 sec, 150 bullets strike and embed themselves in a wall. The bullets, each of mass 30 g, strike the wall perpendicularly at a speed of 1100 m/s.

(a) What is the average change in momentum per second for the entire set of bullets?

(b) Determine the average force exerted on the wall.

(c) Assuming that the bullets are spread out evenly over an area of 2.5×10^{-4} m^2, obtain the average pressure they exert on the wall.