Week 13- Problems

13-1. In the laboratories on the second floor, the best vacuum is about 10^{-11}mm Hg at room temperature. Estimate the number of molecules per cm^3 in this vacuum. (density of Hg is $13.6x10^3 kg/m^3$, Boltzmaman's constant $k_B = 1.38x10^{-23} J/k$)

13-2. A bubble of air of $1cm^3$ starts at the bottom of a lake of depth 2m where the temperature is 15°C. Calculate its volume just before it reaches the surface if the temperature has risen to 20°C.

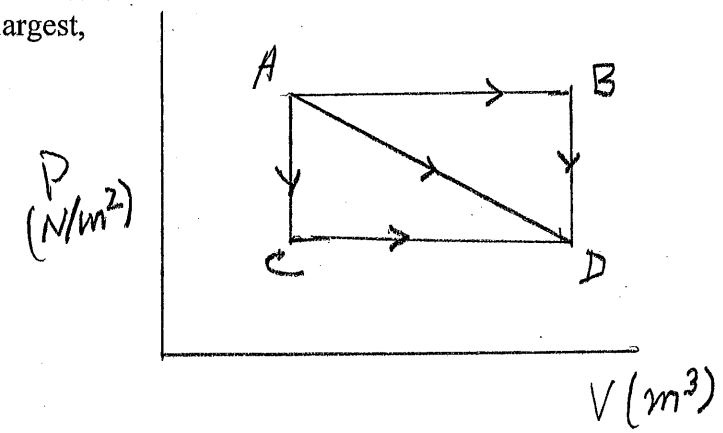
13-3. A gas is held in a stationary enclosure at a temperature of 500K. What is the average velocity of its molecules? Why?

13-4. Prove that when a gas molecule collides with the walls of its container, and the collision is totally elastic, it will leave with the same kinetic energy with which it arrived.

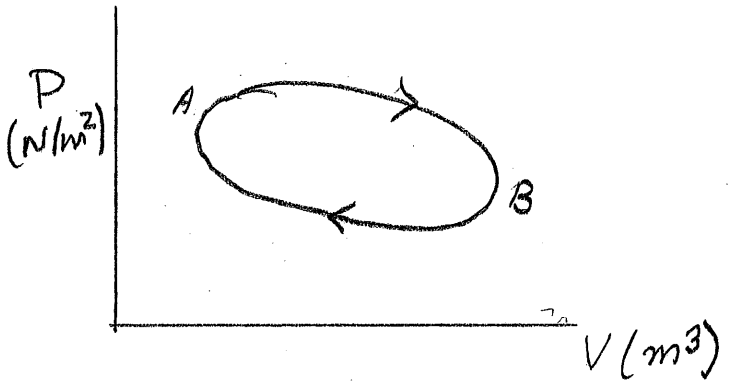
13-5. A cylinder at 500K contains a mixture of Helium ($m = 4x1.6x10^{-27}kg$) and Krypton ($m = 84x1.6x10^{-27}kg$). (i) Which atoms have the higher kinetic energy and by what factor? Why? (ii) Which atoms have the higher r.m.s. speed and by what factor? Why?

13-6. Starting with a 2 mols of monatomic gas at 20°C. If you do not want to change the volume but want to double the pressure, what temperature would you require? By what factor will the r.m.s. speed of the particles change during the process?

13-7. As shown in the diagram a gas is carried from A to D via three thermodynamic processes. In which case is the work done (i) largest, (ii) least? Why?



13-8. A gas is carried through the closed loop process shown in the figure:
(i) Show that the work done in going around the loop is equal to the area of the loop.
(ii) In this process which entity does more work, the gas or the experimenter? Why?

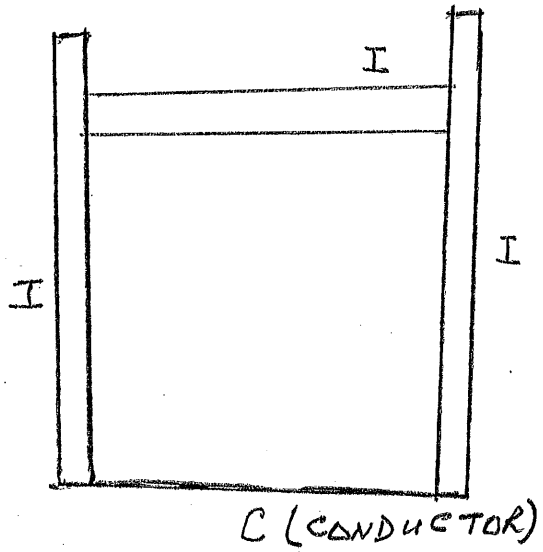


13-9. In the process of Problem 13-6, (i) what is work done? (ii) What is the change in the internal energy?

13-10. Explain clearly the differences between (i) mechanical equivalent of heat, (ii) heat and (iii) internal energy.

13-11. For the process shown in 13-7b, (i) what is the change in internal energy during a complete loop? (ii) Do you need to add or subtract heat to carry out the loop?

13-12. The picture shows a thermodynamic system consisting of a certain amount of gas. Apart from the bottom (C) all the walls and piston are insulators (I). Discuss the three modes in which the gas can change its energy indicating clearly which of the changes are path dependent and which change is intrinsic to the gas?



13-13. a) The thermodynamic processes are (i) isochoric, (ii) isobaric, (iii) isothermic, (iv) adiabatic. Explain each carefully and draw each on a P-V diagram.
b) If the curves for (iii) and (iv) intersect, which is steeper? Why?

13-14. For a solid or liquid the specific heat can be written as $C = \frac{DQ}{m\Delta T}$ for all processes. For a gas, the specific heat depends on the process. Explain!