Physics 224A **Problem Set 6** Due May 18, 2006

Questions for grading:

1. (a) A container full of helium gas at 273 K has diameter .10 m. This is then attached to a vacuum pump. At what pressure will the mean free path of the atoms be equal to the diameter of the container?

(b) If the temperature of the vapor is 1.5 K, at what pressure will the mean free path of the atoms be equal to the diameter of the container?

2. **This question counts as a double question.**

(a) The viscous force on a sphere of radius a, mass m, moving with velocity $\mathbf{v}$ in a fluid whose coefficient of viscosity is η, is $-6\pi\eta a\mathbf{v}$. Show that the speed of the sphere subject to no other forces drops by a factor e in a time $\tau = m/6\pi\eta a$.

(b) In Brownian motion of particles suspended in a fluid this time τ serves as the collision time determining the time between steps in a random walk. How long is τ for a spherical particle of radius $a = 0.50 \times 10^{-6}$ m, made of material whose mass density is 1200 $\mathrm{kg/m^3}$, suspended in water, for which the coefficient of viscosity at 20 C is 1.0×10^{-3} kg/m s?

(c) What is the root mean square speed of this particle at 20 C due to thermal motion?

(d) What is the root mean square distance traveled in time τ?

(e) What is the root mean square distance traveled in one second?

(f) How rapidly does the concentration of the particles fall off with height if this suspension is in thermal equilibrium under gravity? Do not forget about buoyancy.

3. (from Knight, problem 19.53) A heat engine using a diatomic gas with $C_p/C_V = 7/5$ uses the cycle shown in the figure. Its temperature at point 1 is 20 C.

(a) Determine the work output W, the heat input Q and the change of internal energy ΔU for each of the three processes in the cycle. Display your results in a table.

(b) What is the ratio of the total work done round the cycle to the heat input from 1 to 2? This is what is defined as the efficiency of the engine.

(c) What is the power output of the engine if it runs at 500 revolutions per minute?

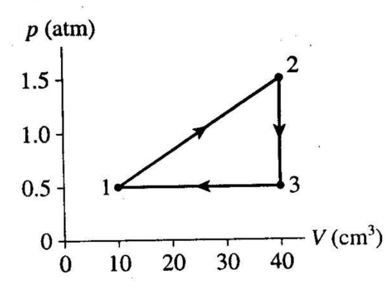

Figure 1: **Triangular cycle**