THE UNIVERSITY OF BRITISH COLUMBIA

Physics 122 Assignment # 2:

KINETIC THEORY OF GASES

Wed. 09 Jan. 2002 — finish by Wed. 16 Jan.

1. One-Dimensional Ideal Gas

Making use of the EQUIPARTITION THEOREM, derive an equation analogous to the familiar 3D IDEAL GAS LAW ($pV = N\tau$) for an ideal gas confined to a **one**-dimensional "box" of length L. (Some examples would be N electrons moving freely along a single DNA molecule, a *trans*-polyacetylene chain or a "nanowire" made from GaAs/AlGaAs structures.)

2. One-Dimensional Maxwellian Speed Distribution

(*a*) What is the thermal speed distribution $\mathcal{D}(v)$ [in the textbook's notation, $N(v)/N$, as in Eq. (22-14) on p. 503] for an ideal gas confined to a **one**-dimensional "box"? It would be nice if you could find the right leading factors (involving temperature and various constants) to *normalize* the distribution so that

$$\int_0^\infty \mathcal{D}(v)\, dv \;=\; 1 ,$$

but I am mainly looking for its *dependence on the speed* v.

Hint: Use de Broglie's hypothesis ($\lambda = h/p$) and think in terms of *standing waves*.

(*b*) *Sketch* this distribution for a given temperature and compare its shape with that shown in the Figures on p. 503 of the textbook.

(*c*) What can you say about the *most probable speed* v_{p} in the two different cases?

3. Heat Capacity of Nitrogen Gas

Sketch (including axis labels *and scales*) the *heat capacity per molecule*, C_1, of an ideal gas of diatomic nitrogen (N_2) molecules in an isolated closed vessel of fixed volume, as a function of temperature τ from room temperature[1] up to a temperature high enough to dissociate the molecules into separate atoms. You may have to make some estimates based on simple mechanics and common sense.

[1] At atmospheric pressure, solid nitrogen melts at 68 K and liquid nitrogen boils at 77 K.