

## Models of A gas

- a gas consists of a large number of very small things flying about randomly.

Not necessary to assume particles are

- strictly point like
- small compared to the average distance.

## Hard Spheres Model

- particles have some finite sizes.
- interaction limited to collisions.

L: diameter of the container

s: average separation between the molecules

r<sub>c</sub>: radius of a single molecule

$\lambda$ : average distance travelled by any given molecules before hitting another

$$L \gg \lambda \gg s \gg r_c$$

e.g.  $10^{-2} \gg 10^{-7} \gg 3 \times 10^{-9} \gg 10^{-10}$

The inequality may not hold when the density of the gas is very high or low.

## Internal States

A molecule can rotate and vibrate.

Internal states can be allowed for quite easily by averaging.

## The Quantum limit.

- whether quantum theory is needed depends on the degree of approximation.
- At thermal equilibrium or around it, the classical treatment yields accurate results as long as the particles are not so densely packed.

Thermal energy:  $k_B \cdot T$

Momentum:  $p = \sqrt{2m k_B T}$

De Broglie wavelength:  $\lambda = \frac{h}{p} = \frac{2\pi h}{\sqrt{2m k_B T}}$

$n$ : the number of gas particles per unit volume

$$n\lambda^3 \ll 1$$

If this inequality holds, then Newtonian Physics is sufficient to treat the motion of the particles.