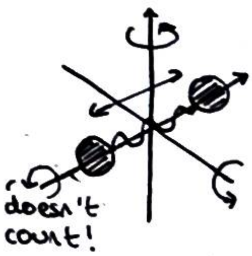
Equipartition Theorem

Now that we have the maxwell-boltzmann distribution, we don't have to only focus on monoatomic gases anymore, we can also compute the energy of gases that store energy in other ways.

> The Equipartition Theorem states that in a system in Thermal Equilibrium, the average energy of a molecule with f degrees of freedom is $U = \frac{f}{2} k_B T$

So, taking a diatomic molecule:



Much like with a monoatomic particle, this molecule has 3 translations: x, y and z. It also has 3 rotations, one of which doesn't count since it has no effect.

The molecule can also vibrate, which stores energy in both the compression and extension.

So:

3 x translations
2 x rotations
2(1) x vibrations

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7 degrees of freedom

So, according to equipartition theorem, this has internal energy:

$$U = \frac{7}{2} k_B T$$

Failures of Equipartition Theorem

When the internal energy of gases is measured experimentally, the equipartition theorem doesn't always work. This is because energy is quantised!

For translations $E \sim \frac{\pi^2 \hbar^2}{mL^2} \sim 10^{-35} J \sim 10^{-18} eV$ } This can occur at room temp.

For rotations $E \sim \frac{\hbar^2}{2I} \sim 1 meV$ } This barely occurs at room temp.

For vibrations $E \sim \hbar\omega \sim 10 meV$ } This doesn't occur at room temp.

Some degrees of freedom are "frozen out" since there is not enough thermal energy at room temperature to happen. Since energy is quantised, if they are below the quanta, the degree of freedom doesn't happen!