Degree of freedom

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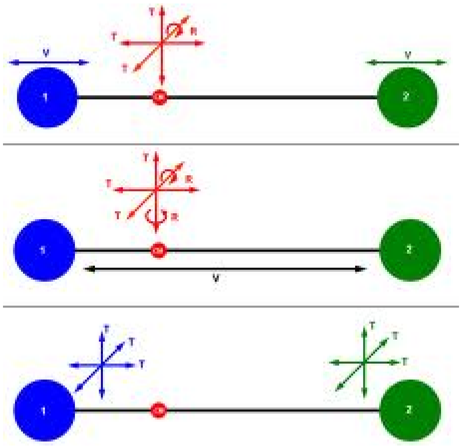
Introduction to Degree of freedom



The number of independent directions in which a system (or gas molecule) can move, are called the number of degrees of freedom of that system or molecule.

The number of degree of freedom is required to express the position, energy and motion of a system.

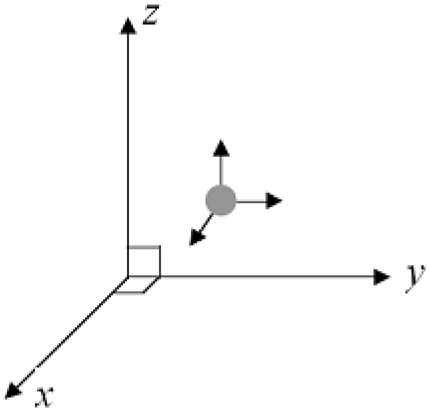
If a particle in motion is confined to a straight line, it has only one translational degree of freedom, while if the same particle is confined to move in a plane, it will have two translational degrees of freedom.

If the particle is free to move in space, it will have three translational degrees of freedom.

Types of Energy

A gas molecule can have following types of energies:
(a) Translational kinetic energy
(b) Rotational kinetic energy
(c) Vibrational kinetic energy

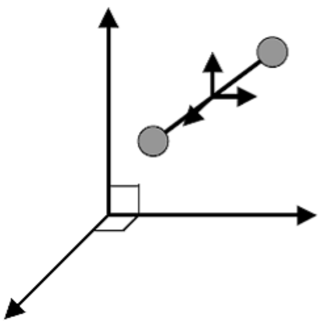
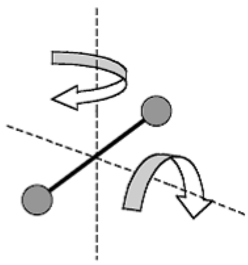
Monatomic gases


Figuring out the degree of freedom for monatomic gases is simple because internal energy is stored only in the translational motion of the atoms. That is, the atoms move as a point-like body and can move in three independent directions.

For a monatomic gas, there are three translational degrees of freedom corresponding to the three axes of movement.

As its rotational moment of inertia is very low (due to small atomic radius), the degree of freedom associated with rotation does not make an appreciable contribution to the kinetic energy. Therefore, a monatomic gas has 3 degrees of freedom.
Degree of freedom f = 3 (all translational)

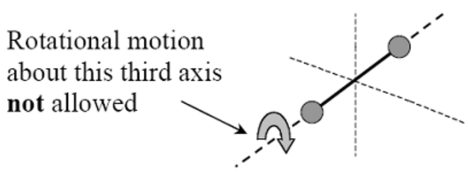
Diatomic gases



For diatomic and polyatomic molecules, rotational motion is significant.

In these cases both translational and rotational motion can contribute tothe heat capacity:
For a diatomic gas, in addition to the three degrees fortranslatory motion, there are two degrees of rotatory motion around axes perpendicular to the bond between the atoms.

Degree of freedom, f = 5 (3 translational +2 rotational) at room temperature f = 7 (3 translational+2 rotational+2 vibrational) at high temperature

Polyatomic gas



A polyatomic (non-linear) molecule (such as NH3) can rotate about any of three co-ordinate axes. Hence it has 6 degrees of freedom, 3 translational and 3 rotational. At room temperature, apolyatomic gas molecule has vibrational energy greater than that of a diatomic gas. The atoms within the molecule may also vibrate with respect to each other at high temperature. In such cases, the molecule will have an additional degree of freedom, due to vibrational motion. The vibrational motion of a molecule can contribute as much as to two further degrees of freedom. Vibrational motion is not allowed with diatomic molecules but can occur with polyatomic molecules

Degree of freedom, f = 6 (3 translational +3 rotational) at room temperature
f = 8 (3 translational+3 rotational+2 vibrational) at high temperature

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Reference links

- http://www.en.wikipedia.org/wiki/Kinetic_energy
- http://www.en.wikipedia.org/wiki/temperature
- http://www.hyperphysics.phy-astr.gsu.edu/hbase/thermo/inteng.html
- http://www.chm.davidson.edu/vce/calorimetry/heatcapacity.html

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