Equipartition of Energy

Created: Tuesday, 30 August 2011 06:51 | Published: Tuesday, 30 August 2011 06:51 | Written by Super User | Print

Introduction to the Equipartition of Energy

The **equipartition of energy** theorem states: each degree of freedom contributes on average ½*kT* per molecule to the stored energy of a gas. *k* is Boltzman's constant, i.e., k = R/ N = 1.38 x 10-23 T/K. R = the universal gas constant and N = Avogadro number

Thus for a monatomic molecule of an ideal gas which has three **degrees of freedom** per molecule kinetic energy *=3/2 kT* (for one molecule of gas):

$\frac{1}{2}kT$	per molecule	k = Boltzmann's constant	$\frac{3}{2}kT$	For three translational degrees of freedom, such as in an ideal monoatomic gas.
$\frac{1}{2}RT$	per mole	R = gas constant	$\frac{3}{2}RT$	

The equipartition result is as follows:

$$KE_{avg} = \frac{3}{2}kT$$

Equipartition energy for diatomic gases

Similarly, a molecule of diatomic gas has 5 **degrees of freedom** per molecule. Therefore, kinetic energy per molecule is 5/2*kT* and mean kinetic energy per mole is 5/2*kT* × *N* (where *N* is number of molecules in one mole; N is called the Avogadro number) . Further the number of molecules per cc at NTP in all gases is the same and is independent of the nature of gas. This number is called Loschmidt's number.

We say that the different 'modes' (translational, rotational or vibrational modes) are excited, i.e. they 'come into play', and contribute to the heat capacity of a gas in different temperature ranges. At low temperatures, only translational modes are excited – i.e., *cV* is 3/2*R* per mole, and the rotational and vibrational modes are said to be 'frozen out'.

The measured value of *cV* around room temperature (~300 K) is 5/2*R*: both translational (3 modes) and vibrational modes (2 modes) contribute.

Total Translational energy

The total translational energy of all the molecules of a gas is

$$K.E = \sum \frac{1}{2} m v^2 = \frac{1}{2} m N \frac{\sum v^2}{N} = \frac{1}{2} M v_{rms}^2 \quad \text{-----(vii)}$$

The average kinetic energy of a molecule is

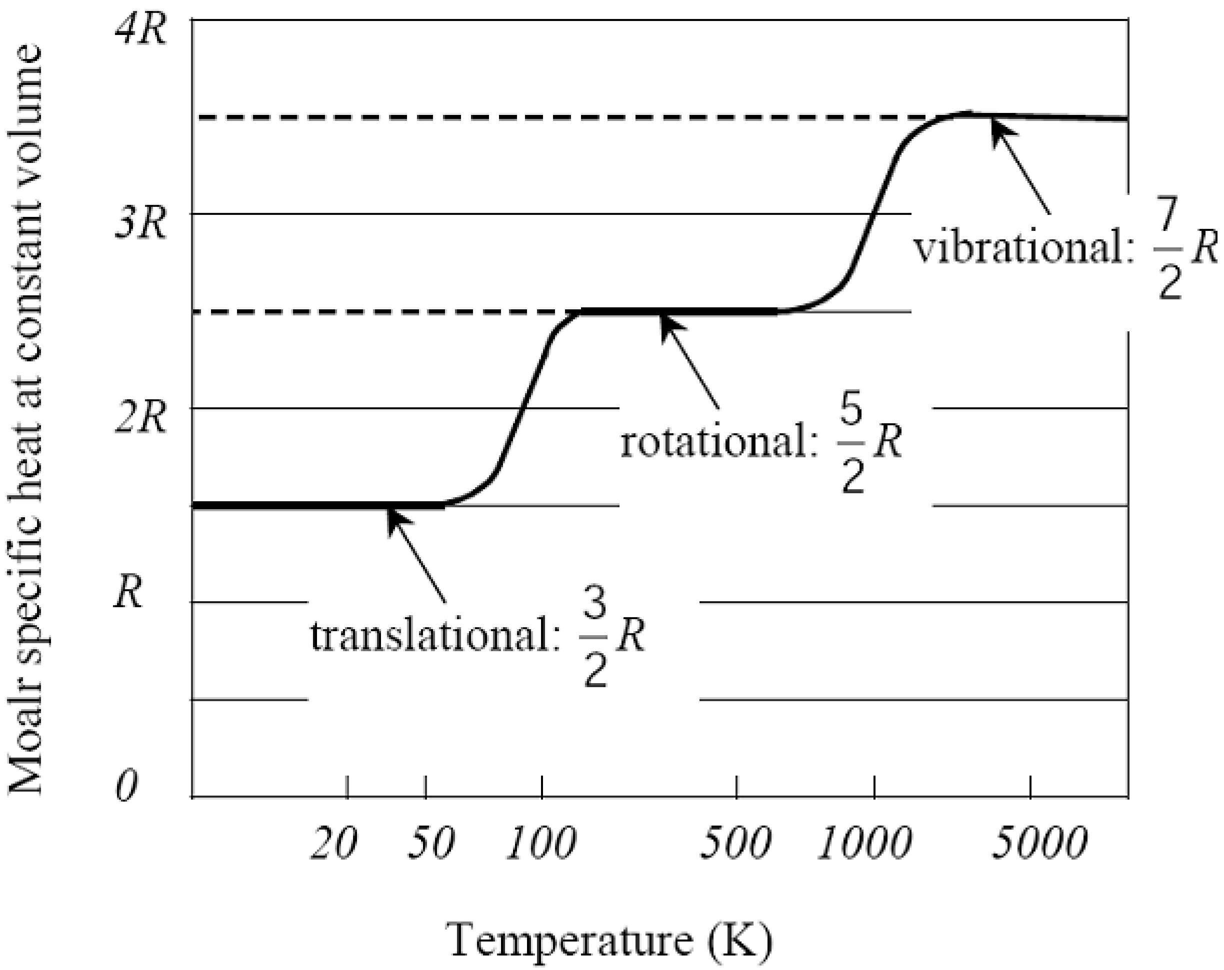
$$\frac{K.E}{N} = \frac{1}{2}\frac{M}{N} v_{rms}^2 = \frac{1}{2} m v_{rms}^2$$

$$PV = \frac{2}{3} \times \frac{1}{2} M v_{rms}^2$$

$$\text{or } PV = \frac{2}{3} K.E$$

$$\text{or } K.E = \frac{3}{2} PV$$

Experimentally, the contributions of the degrees of freedom to energy can be observed in measurements of cV.



Want to know more about the equipartition of energy?[Click here](#) to schedule a live session with an eAge eTutor!

About eAge online Tutoring

eAgeTutor.com is the premium online tutoring provider. Using materials developed by highly qualified educators and leading content developers, a team of top-notch software experts, and a group of passionate educators, eAgeTutor works to ensure the success and satisfaction of all of its students.

Contact us today to learn more about our guaranteed results and discuss how we can help make the dreams of the student in your life come true!

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

Category:ROOT