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Alternate Proof For Expression of Most Probable Speed of Gas

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Introduction

Most probable speed is the speed most likely possessed by any gas(of the same mass) in the system.It can be derived using Maxwell-Boltzmann distribution function [1] for ideal gases.I will provide an alternate derivation by using the definition, gas laws and kinetic theory of gases.

Preliminaries

Boyles's law:The absolute pressure exerted by given mass of an ideal gas is inversely proportional to the volume it occupies if the temperature and amount of gas remains unchanged with in a closed system [2]. In an elastic collision the total kinetic energy of the system is constant [3].

Main Result

The most probable speed of the gas is given by,

$$\mathrm{V_P} = \sqrt{\frac{2\mathrm{RT}}{M}}$$

where $\mathrm{V_P}$ is the most probable speed of the gas, R is the universal gas constant, T is the absolute temperature of the system and M is the molecular mass of the gas. Proof:Consider a given amount of ideal gas in a closed system at constant temperature. By Boyle's

$$\mathrm{pv} = \text{constant}$$

and for a given amount of gas and at constant temperature by assumptions of kinetic theory of gases

$$\frac{1}{2}\left(\mathrm{mV_1^2} + \mathrm{mV_2^2} + ... + \mathrm{mV}_N^2\right) = \text{constant}$$

since equation one and two are constant for same parameters and dimensionally energies,we can equate them

$$\frac{1}{2}\left(\mathrm{mV_1^2} + \mathrm{mV_2^2} + ... + \mathrm{mV}_N^2\right) = pv$$

$$\frac{m}{2}\left(\mathrm{V_1^2} + \mathrm{V_2^2} + ... + \mathrm{V}_N^2\right) = pv$$

,using the definition of most probable speed,lets say all of the molecules are moving with $\mathrm{V_P}$

$$\frac{m}{2}\left(\mathrm{V}_P^2 + \mathrm{V}_P^2 + ... + \mathrm{V}_P^2\right) = pv$$

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$$\frac{\mathrm{Nm}}{2}\mathrm{V}_p^2 = pv$$

,where N is the total number of molecules and Nm is the mass of the gas

$$\frac{\mathrm{NmV}_p^2}{2v} = p$$

But,

$$\frac{Nm}{v} = d$$

,d=density of the gas

$$\frac{\mathrm{dV}_P^2}{2} = p$$

$$p = \frac{dRT}{M}$$

$$\mathrm{dV}_p^2 = \frac{2\mathrm{dRT}}{M}$$

$$\mathrm{V}_P^2 = \frac{2\mathrm{RT}}{M}$$

$$V_p = \sqrt{\frac{2\mathrm{RT}}{M}}$$

hence proved.

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