

[TP] The rms speed, u_{rms}, of O_2 at 25 °C is about ...
("Use units, Luke!" $R = 8.314 \frac{\text{J}}{\text{K mol}} = 8.314 \frac{\text{kg m}^2/\text{s}^2}{\text{K mol}}$)

25% 1. 250 m/s
25% 2. 500 m/s
25% 3. 750 m/s
25% 4. 1000 m/s

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Response Counter 10 1

Lecture 6 CH102 A2 (MWF 11:15 am)

Monday, February 4, 2019

- Molecular speeds and their distribution, CDF https://goo.gl/VkRrsg

Next: Real gases: Effect of molecular attraction; Real gases: Effect of molecular size; van der Waals equation; Phase diagrams

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Calculation of molecular speeds

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Response Counter 10 6

Calculate rms speed of O_2 at 25 °C

$$u^2_{\text{avg}} = \frac{3RT}{M}$$

$$u_{\text{rms}} = \sqrt{u^2_{\text{avg}}} = \sqrt{\frac{3RT}{M}}$$

$$R = 8.314 \frac{\text{J}}{\text{K mol}} = 8.314 \frac{\text{kg m}^2/\text{s}^2}{\text{K mol}}$$

Answer: 482 m/s ≈ 500 m/s

Distribution of molecular speeds

Distribution of speeds is a plot of the number of particles (y axis) at each speed (x axis).

Distribution of molecular speeds

Say we 20,000 particles, all with the same speed $u = 500$ m/s.

Make a sketch of the corresponding distribution of speeds.

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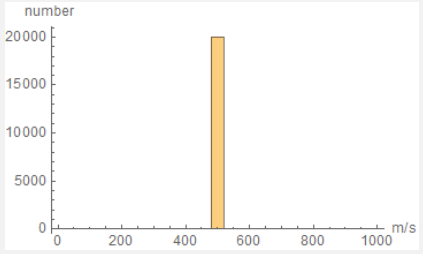

Distribution of molecular speeds

We have said that collisions between gas particles results in the particles having different speeds.

Make a sketch of a possible distribution of just three speeds, 300, 500, and 700 m/s, of the 20,000 particles.

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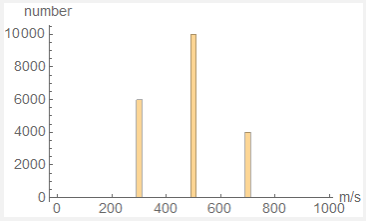

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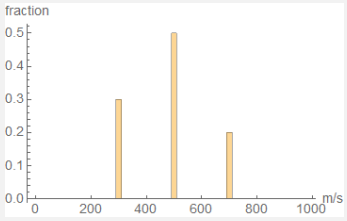
Distribution of molecular speeds

We have said that collisions between gas particles results in the particles having different speeds.

It is convenient to express the distribution in terms of fractional number of particles rather than number of particles.



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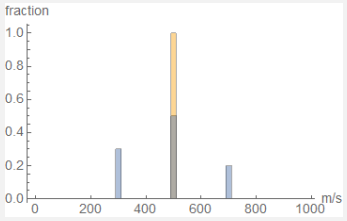

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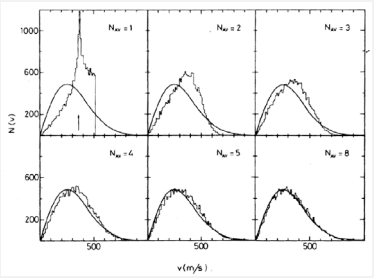
Distribution of molecular speeds

Here is what happens to the speeds of 20,000 particles, all initially at the same speed, after they each have undergone successive numbers of collisions.

Bonomo & Riggi,
Am. J. Phys. ,Vol 52, p 54 (1984)
http://dx.doi.org/10.1119/1.13809



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Distribution of molecular speeds

At 300 K, the rms speed of O_2 is $u_{rms} = 500$ m/s.

Sketch the Maxwell-Boltzmann distribution of speeds of O_2 at 300 K, from 0 m/s to 4000 m/s, marking the position of u_{rms} on the x axis.

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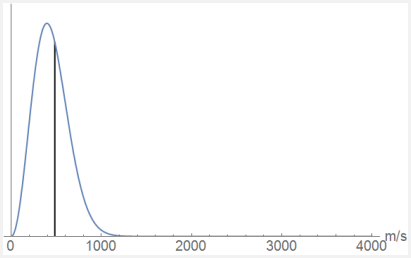

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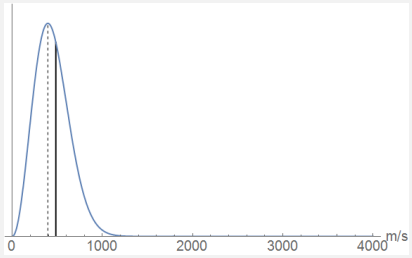
Distribution of molecular speeds

The rms speed, u_{rms}, is slightly higher than the most probable speed, u_{mp}, because of the exponential tail extending to very high speeds.

$u_{\mathrm{mp}} = \sqrt{2/3}\ u_{rms} \approx 0.82\ u_{rms}$



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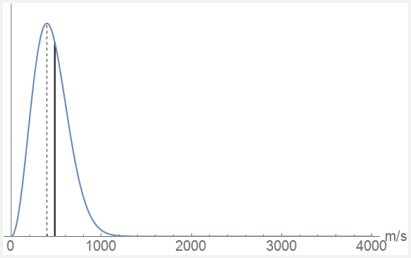
u_{rms} versus temperature

The rms speed of O_2 at 300 K is 500 m/s and the rms speed of O_2 at 1200 K is 1000 m/s. Sketch the distribution of speeds for O_2 at these two temperatures on the same axes, marking the position of the two rms speeds on the x axis.



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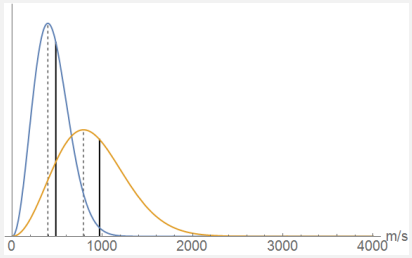

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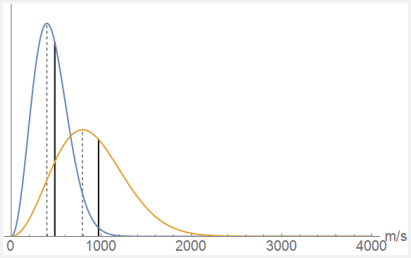
u_{rms} versus temperature

Add to your sketch the distribution of speeds of H_2 at 300 K.



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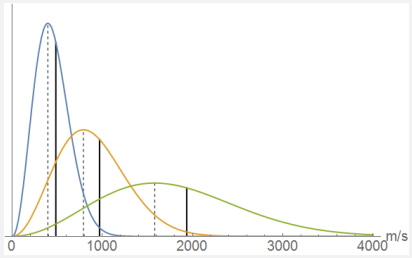
u_{rms} versus temperature

Add to your sketch the distribution of speeds of H_2 at 300 K.



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