CHEM 6B WI24 F02-F06

Week 2: kinetic-molecular theory of gases

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Statistics: mean

- Average of a data set x_i/probability distribution $p(x_i)$ (discrete) or $f(x)$ where x lives in $[a, b]$ (continuous) is defined as

$$x_{\text{mean}} = \frac{1}{N} \sum_i x_i \text{ or } \sum_i x_i p(x_i) \text{ or } \int_a^b x f(x) \, \mathrm{d}x \tag{1}$$

  where N is the size of the dataset (discrete).

- Example: given a set of numbers

$$1, 1, 3, 3, 3, 4$$

  Calculate the mean of this dataset.

Statistics: mean square & root mean square

- Mean square is the mean of square

$$x_{\text{ms}} = \frac{1}{N}\sum_i x_i^2 \text{ or } \sum_i x_i^2 p(x_i) \text{ or } \int_a^b x^2 f(x)\,\mathrm{d}x \tag{2}$$

- Example: given a set of numbers

$$1, 1, 3, 3, 3, 4$$

  Calculate the root mean square of this dataset.

Statistics: mode

- Mode is the value in the dataset which gives the maximum probability (i.e., the most probable value)

$$x_{\text{mp}} = \sum_i \arg\max_{x_i} p(x_i) \text{ or } \arg\max_x f(x) \tag{3}$$

- Example: given a set of numbers

$$1, 1, 3, 3, 3, 4$$

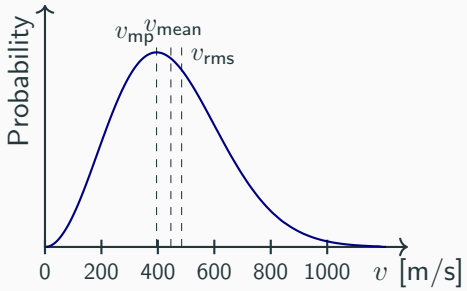
Calculate the mode of this dataset.

Kinetic theory of gas

- Three essential statistical values for gas. v_{mp}: most probable. v_{mean}: average. v_{rms}: root-mean-square.

$$v_{\text{mp}} = \sqrt{\frac{2RT}{M}}, \quad v_{\text{mean}} = \sqrt{\frac{8RT}{\pi M}}, \quad v_{\text{rms}} = \sqrt{\frac{3RT}{M}} \tag{4}$$

- $v_{\text{mp}} < v_{\text{mean}} < v_{\text{rms}}$.



Problems

Activity 1.1

Measurement on a noble gas sample at a temperature of $1000\,\mathrm{K}$ show a discribution of molecular speeds characterized by a root mean square speed of $1.12 \times 10^3\,\mathrm{ms}^{-1}$. What noble gas is this?

Problems

Activity 1.2

Consider two Maxwell-Boltzmann speed distribution curves below

a. If the curve represent the speed distributions for argon and helium at the same temperature, which curve (1 or 2) best depicts the behavior of helium?

b. If the curves represent the speed distributions for helium gas at two different temperatures, T_1 and T_2 (where $T_2 > T_1$), which curve (1 or 2) best depicts the hither temperature sample?