

Answer on Question 50641, Physics, Molecular Physics | Thermodynamics

Question:

What is meant by root mean square speed of a gas? Express it in terms of temperature and molecular weight of gas. Calculate v_{rms} for He atoms at **300K**. (Take $m_{He} = 6.67 \cdot 10^{-27} kg$.)

Solution:

The root mean square speed is the measure of the speed of particles in a gas, defined as the square root of the average velocity-squared of the molecules in a gas. We can write it in terms of temperature and molecular weight of gas:

$$v_{rms} = \sqrt{\frac{3RT}{M_m}}$$

where, $R = 8.3145 \frac{J}{K \cdot mol}$ is the molar gas constant, T is the temperature in Kelvin and M_m is the molar mass of the helium gas in kilograms per mole ($M_m = m_{He} \cdot N_A$, where m_{He} is the mass of one molecule of the helium gas and $N_A = 6.022 \cdot 10^{23} \frac{1}{mol}$ is the Avogadro constant). So, for helium atoms at **300K** we obtain:

$$v_{rms} = \sqrt{\frac{3RT}{M_m}} = \sqrt{\frac{3RT}{m_{He} \cdot N_A}} = \sqrt{\frac{3 \cdot 8.3145 \frac{J}{K \cdot mol} \cdot 300K}{6.67 \cdot 10^{-27} kg \cdot 6.022 \cdot 10^{23} \frac{1}{mol}}} = 1365 \frac{m}{s}.$$

Answer:

$$v_{rms} = 1365 \frac{m}{s}.$$