

CONCEPT: ROOT-MEAN-SQUARE SPEED OF IDEAL GASES

- The **root-mean-square** (RMS) speed of an ideal gas is a type of _____ speed.
 - As the name suggests, it is the square _____ of the _____ (average) of the _____ of each particle's speed.
 - In general, $n_{rms} \neq n_{avg}$

EXAMPLE: Using the numbers **5**, **11**, and **32**, calculate:

a) The average (n_{avg})

a) The RMS (n_{rms})

$$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + \dots + v_n^2}{n}} = \sqrt{\frac{v_1^2 + v_2^2 + \dots + v_n^2}{n}}$$

- Remember, m = mass [kg] while M = molar mass [kg/mol]
- T **MUST** be in Kelvin (K)

THERMO CONSTANTS

$$k_B = 1.38 \times 10^{-23} \frac{J}{K}$$

$$R = 8.314 \frac{J}{mol \cdot K}$$

EXAMPLE: Calculate the rms speed of diatomic hydrogen gas (H_2) at $27^\circ C$. For H_2 , the molar mass $M = 2$ g/mol.

- v_{rms} is the “average” speed of particles; many are going above & below that speed.

PROBLEM: What is the temperature of a sample of CO₂ molecules whose rms speed is 300 m/s? The molecular mass for Carbon and Oxygen is 12.01 g/mol and 16 g/mol, respectively.

- A) 158.7 K
- B) 529.2 K
- C) 1.7×10^5 K
- D) 1391 K

IDEAL GAS EQs & Constants	
$PV = nRT = Nk_B T$	
$K_{av} = \frac{3}{2} k_B T$	
$E_{int} = \frac{3}{2} nRT$	
$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$	
$R = 8.314 \frac{J}{mol K}$	
$k_B = 1.38 \times 10^{-23} \frac{J}{K}$	
$N_A = 6.02 \times 10^{23}$	

PROBLEM: You fill a 1.6L container filled with 200g of an ideal gas, which has a molecular mass of 28g/mol. If the RMS speed of the gas molecules is 600 m/s, what is the pressure of the gas?

IDEAL GAS EQs & Constants	
$n = \frac{m}{M}$	
$PV = nRT = Nk_B T$	
$K_{av} = \frac{3}{2} k_B T$	
$E_{int} = \frac{3}{2} nRT$	
$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$	
$R = 8.314 \frac{J}{mol K}$	
$k_B = 1.38 \times 10^{-23} \frac{J}{K}$	
$N_A = 6.02 \times 10^{23}$	
CONVERSIONS	
$1L = 0.001 m^3$	
$1 atm = 1.01 \times 10^5 Pa$	