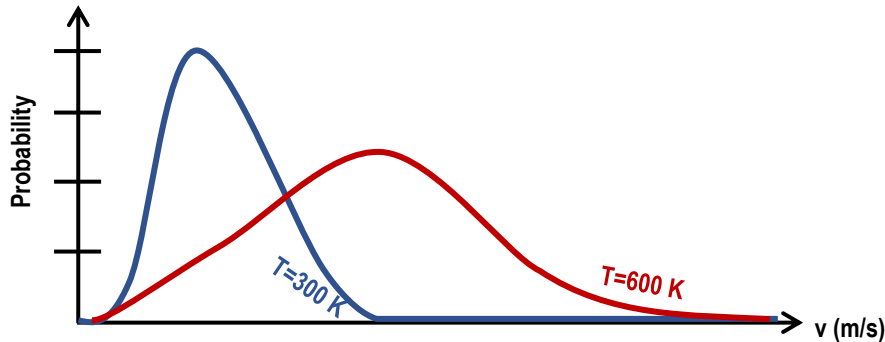


CONCEPT: SPEED DISTRIBUTION OF IDEAL GASES

- Gas particles do not all travel at the same speed. As they collide, particles speed up and slow down randomly.
 - If you plotted the # of particles vs. the speeds, you get a _____ (a.k.a **Maxwell-Boltzmann Distribution**)

EXAMPLE: The speed distributions for an ideal gas at different temperatures is shown below. The ideal gas particles have a molar mass of 28 g/mol. **a)** Calculate the most probable, average, and RMS speeds of gas particles in a sample at 300K. **b)** If you picked a particle from the 600K gas sample at random, what is the speed you'd most likely measure?



- There are 3 special speeds you need to know:

Most Probable (Likely) Speed

$$v_{MP} = \sqrt{\frac{2k_B T}{m}} = \sqrt{\frac{2RT}{M}}$$

- Highest probability = _____ of the curve

Average Speed

$$v_{avg} = \sqrt{\frac{10k_B T}{m}} = \sqrt{\frac{10RT}{M}}$$

- True average

RMS Speed

$$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$$

- Type of average skewed to higher v

- For any given temperature, $v_{MP} \text{ --- } v_{avg} \text{ --- } v_{rms}$

- In general, all 3 speeds increase as T increases, and the curve gets flatter.

PROBLEM: The escape velocity from the Earth is approximately 11.2 km/s. If the mass of helium atoms is 6.64×10^{-27} kg, at what temperature would the average speed of helium atoms be equal to the escape velocity?

- A) 2361 K
- B) 2.11 K
- C) 4.5×10^{-42} K
- D) 3.9×10^{-20} K

IDEAL GAS EQs & Constants

$$PV = nRT = Nk_B T$$

$$v_{MP} = \sqrt{\frac{2k_B T}{m}} = \sqrt{\frac{2RT}{M}}$$

$$v_{avg} = \sqrt{\frac{8k_B T}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$$

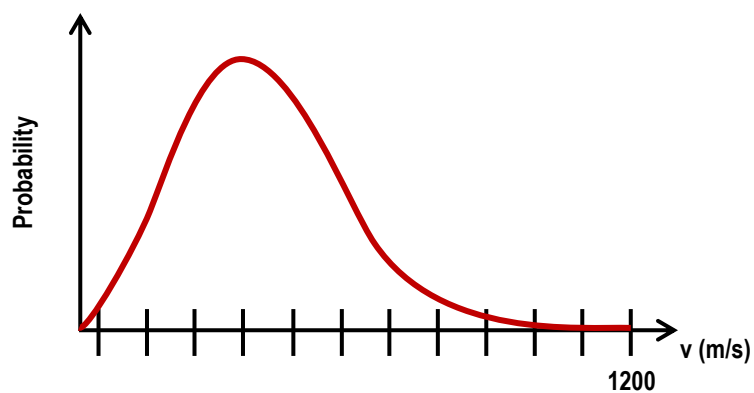
$$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$$

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

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

$$N_A = 6.02 \times 10^{23}$$

PROBLEM: The graph below plots the probability distribution for oxygen, which has a molar mass of 32 g/mol. The farthest tick on the x-axis is set to 1200 m/s. What is the temperature of this sample of oxygen gas?



IDEAL GAS EQs & Constants

$$PV = nRT = Nk_B T$$

$$v_{MP} = \sqrt{\frac{2k_B T}{m}} = \sqrt{\frac{2RT}{M}}$$

$$v_{avg} = \sqrt{\frac{8k_B T}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$$

$$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$$

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