Chapter 9 Part 4

Dr. Turner

Kinetic Molecular Theory

1. Gases consists of molecules whose separation is much larger than the molecules themselves
2. The molecules of a gas are in continuous, random, and rapid motion
3. The average kinetic energy of gas molecules is determined by the gas temperature, and all gas molecules at the same temperature, regardless of mass, have the same average kinetic energy
4. Gas molecules collide with one another and with the walls of their container, but they do so without loss of energy and no attractive or repulsive forces

Gas Motion

Kinetic Molecular Theory

Which of the following statements concerning kinetic molecular theory is true?

I. The average kinetic energy is determined by the mass and temperature of the gas molecules
II. Gas molecules are constantly in motion
III. Gas molecules lose energy upon collisions with the container

A. I
B. II
C. III
D. I & II

Molar Kinetic Energy

$$\overline{\mathrm{KE}} = \frac{3}{2}\mathrm{RT}$$

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

- $\overline{\mathrm{KE}}$ is the average kinetic energy per mole of gas particles
- R is 8.314 J/(mol K)
- T is the temperature in Kelvin

Molar Kinetic Energy

Which of the following statements concerning the molar kinetic energy is true?

I. Gas molecules with higher masses, on average, have higher kinetic energy
II. Gas molecules with greater temperature, on average, have higher kinetic energy

A. I
B. II
C. Both I and II
D. Neither I nor II

Root mean squared (rms) velocity of gas particles

$$v_{\mathrm{rms}} = \sqrt{\frac{3\mathrm{RT}}{\mathrm{MM}}}$$

$2 \times \overline{\mathrm{KE}}$

R is 8.314 $\frac{\mathrm{J}}{\mathrm{K\ mol}}$

MM is the molar mass in kg/mol

Calculating rms speed

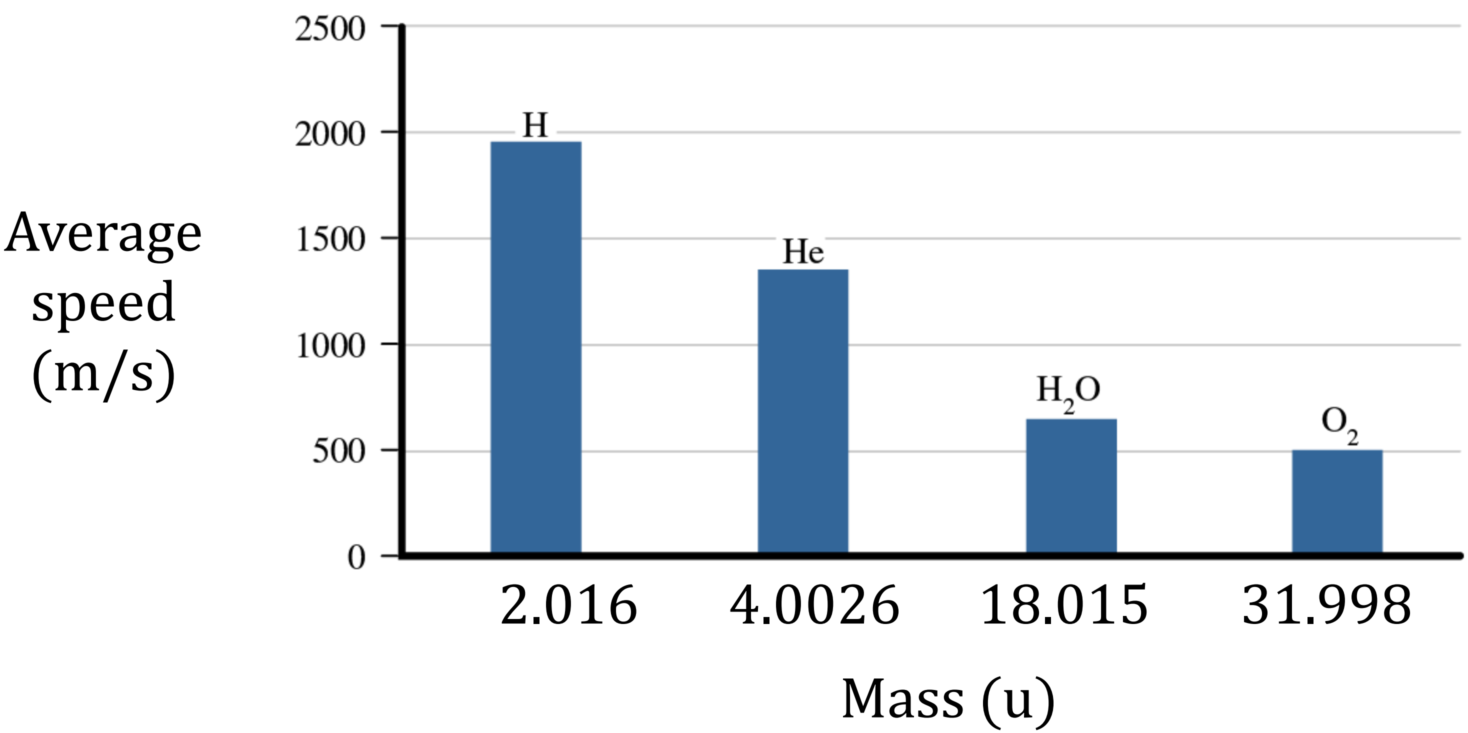
Calculate the rms speed of O_2 molecules in a cylinder at 21.00°C and 15.7 atm.

Increasing the molar mass at constant temperature

- Since kinetic molecular theory mandates that all gases at the same temperature must have the same kinetic energy, gases with smaller masses must move faster
- Thus, heavier gases move more slowly, on average, than lighter gases at the same temperature

$$v_{\mathrm{rms}} = \sqrt{\frac{3\mathrm{RT}}{\mathrm{MM}}}$$

Speed of Gas Particles vs. Molar Mass



Molar mass, particle speed, temperature, and kinetic energy

Describe the relationship between the following pairs as directly or inversely proportional

A. $\overline{KE}$ and T
B. MM and v_{rms} (at constant T)
C. $\overline{KE}$ and v_{rms} (at constant MM)

Real (Nonideal) gases

- Real gases are those which aren’t ideal.
- No gases are truly ideal.
- There are three situation that weaken ideal gas behavior.
  - Large molar masses
  - High pressures
  - Low temperatures

Behaviors that cause nonideal gas behavior

- Gases behave less ideally with increasing molar mass
- Gases behave less ideally at lower temperatures
- Gases behave less ideally at higher pressures

Real gases

Which of the following gases will display the most nonideal behavior at STP?

A. O_2
B. Cl_2
C. NH_3
D. XeF_4