Essential Question

How does particle motion explain gas behavior?

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What Is KMT?

- **Particle level:** individual atoms or molecules moving around a container
- **Macroscopic level:** pressure (P), volume (V), temperature (T), and amount (n)

Kinetic molecular theory (KMT) is a model that links particle motion to gas properties we can measure.

Constant, Random Motion

- Particles move in straight lines until they collide with another particle or a wall.
- They move in all directions at many different speeds. At any moment, a gas contains a range of particle speeds.

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Pressure Comes from Collisions

- Particles hit the container walls, and each hit pushes on the wall.
- Pressure = force ÷ area ($P = F/A$)
- More hits or harder hits → greater pressure. Harder hits happen when particles move faster.

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Compressing a Gas

- Same temperature → same particle speeds
- Smaller volume → more wall hits each second
- More hits → greater pressure

Cutting the volume from V to ½V gives particles less distance to travel between walls, so they hit the walls more often.

Kinetic Energy of a Particle

- **KE** = kinetic energy (J)
- ***m*** = mass of one particle (kg, not g!)
- ***v*** = speed (m/s)

$$KE = \frac{1}{2}mv^2$$

Temperature and Average KE

- Kelvin temperature is proportional to average KE.
- Double the K → double the average KE (the speed does not double, because *v* is squared).
- Always use kelvins! K = °C + 273

The same gas at 400 K has twice the average kinetic energy of the gas at 200 K, so its particles are faster on average.

Same Temperature, Different Gases

- Same temperature → same average KE, no matter what the gas is.
- Lighter particles move faster.

He (4.00 g/mol) and Xe (131.29 g/mol) at 300 K have the same average KE.

Maxwell-Boltzmann Distribution

- Shows the spread of particle speeds at one temperature (speed on the x-axis, number of particles on the y-axis).
- Most particles are near the peak, the most probable speed.
- A few are very slow or very fast. The total area under the curve represents all of the particles.

Maxwell-Boltzmann: Temperature

- Higher T → peak shifts right and gets lower
- More fast particles in the high-speed tail
- Area under the curve stays the same, because the number of particles hasn’t changed

Exam tip: for two curves of the same gas, the flatter curve shifted to the right is at the higher temperature.

Maxwell-Boltzmann: Particle Mass

- Same T → same average KE
- Lighter gas: peak farther right, wider curve
- Heavier gas: slower, taller and narrower curve

He (4.00 g/mol) is about ten times lighter than Ar (39.95 g/mol), so at the same temperature helium’s curve is shifted right and spread out.

Example: Kinetic Energy of a Molecule

Try it first!

An N_2 molecule has a mass of 4.65×10^{-26} kg and moves at 515 m/s. Calculate its kinetic energy.

Example: Changing Temperature

Try it first!

A gas sample is heated from 27 °C to 327 °C. By what factor does the average kinetic energy of its particles increase?

Example: Reading M-B Curves

Try it first!

The graph shows Maxwell-Boltzmann distributions for Ne and Kr at 300 K. Curve X has a tall, narrow peak at a low speed, and curve Y is lower and wider with its peak at a higher speed. Which curve represents Kr? Justify your answer.

Diagram: Two Maxwell-Boltzmann curves at 300 K. Curve X is tall and narrow with its peak at low speed; curve Y is lower and wider with its peak at higher speed.

Big Ideas

- Gas particles are in constant, random motion.
- Wall collisions cause pressure.
- Kelvin T is proportional to average KE.
- M-B curves show the spread of speeds.

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