

Exercise walk-through

9.1

Kinetic Theory of Temperature and Pressure

AP Physics 2

Temperature is energy per particle

Kinetic theory : matter is countless moving particles.

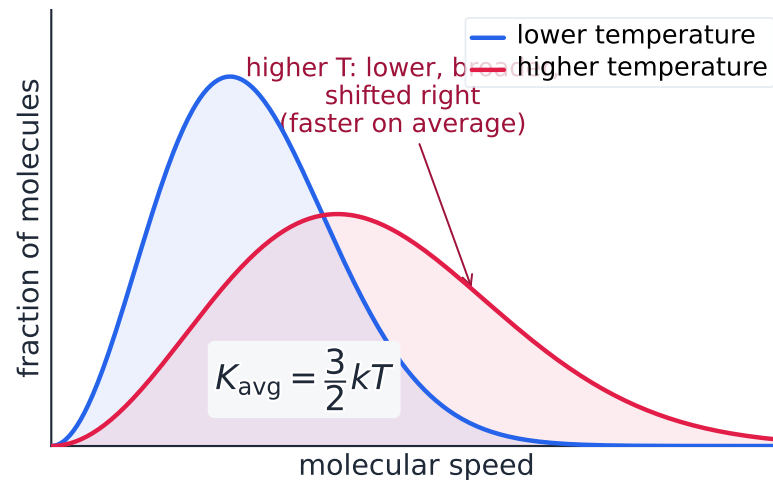
Temperature measures their **average kinetic energy**:

Per particle

$$\bar{K} = \frac{3}{2} k_B T$$

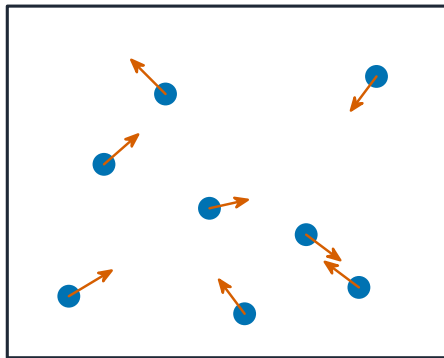
T in kelvin ; $T_K = T_C + 273.15$.

Pressure comes from particles striking the walls – $P = F/A$.



Hotter $\Rightarrow$ the speed distribution shifts right.

Kinetic Theory of Temperature and Pressure



1. many identical molecules, in continuous **random motion**
2. their own volume is **tiny** next to the container
3. straight lines between hits - intermolecular forces **ignored**
4. collisions are **elastic**: no kinetic energy is lost

poor at very high pressure (volume matters) or very low temperature (forces matter)

The key assumptions of the kinetic theory of an ideal gas

Worked example – the average kinetic energy of a molecule

Find the average kinetic energy of a gas molecule at 300 K, with $k_B = 1.38 \times 10^{-23} \text{ J/K}$.

- $K_{\text{avg}} = \frac{3}{2} k_B T$
- $= \frac{3}{2} (1.38 \times 10^{-23}) (300)$
- $= 6.2 \times 10^{-21} \text{ J}$

Temperature *is* average kinetic energy per molecule – and it depends on **neither** the gas's identity **nor** its pressure. Two gases at the same T have the same K_{avg} and different speeds.

Exercises 2.1-2.3

2.1 State what causes the pressure a gas exerts on its container.

[1]

2.2 The absolute temperature of a gas doubles. State what happens to the average kinetic energy of its particles.

[1]

2.3 Find the average kinetic energy of a particle at $T = 300$ K (take $k_B = 1.38 \times 10^{-23}$ J K⁻¹).

[2]

Exercises 2.1-2.3

2.1 State what causes the pressure a gas exerts on its container.

[1]

2.1

- the collisions of the gas particles with the container walls
-

2.2 The absolute temperature of a gas doubles. State what happens to the average kinetic energy of its particles.

[1]

2.2

- it also doubles ($\overline{KE} \propto T$)
-

2.3 Find the average kinetic energy of a particle at $T = 300$ K (take $k_B = 1.38 \times 10^{-23}$ J K⁻¹).

[2]

2.3

- $\overline{KE} = \frac{3}{2}k_B T = \frac{3}{2}(1.38 \times 10^{-23})(300) = 6.2 \times 10^{-21}$ J

Exercises 3.1-3.2

3.1 The absolute temperature of a gas is a measure of the

[1]

☐

A total volume

B average kinetic energy of its particles

C number of particles

D pressure

3.2 If the average kinetic energy of the gas particles triples, the absolute temperature [1]

☐

A stays the same

B doubles

C triples

D falls to one third

Exercises 3.1-3.2

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3.1 B

- average kinetic energy of its particles.

3.2 If the average kinetic energy of the gas particles triples, the absolute temperature [1]

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A stays the same

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D falls to one third

3.2 C

- triples.

Exercise 3.3 (a)

3.3 A gas in a sealed rigid container is heated from 300 K to 600 K.

(a) State the ratio of the new average kinetic energy to the old.

[1]

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(a) State the ratio of the new average kinetic energy to the old.

[1]

(a)

- 2 : 1

Exercise 3.3 (b)

3.3 A gas in a sealed rigid container is heated from 300 K to 600 K.

(b) Explain, in terms of particle motion, why the pressure rises.

[2]

Exercise 3.3 (b)

3.3 A gas in a sealed rigid container is heated from 300 K to 600 K.

(b) Explain, in terms of particle motion, why the pressure rises. [2]

(b)

- higher temperature means faster particles, which hit the walls harder and more often, raising the pressure