

Warm-Up | Pressure



Temperature and Motion

As temperature increases, the **kinetic** energy and motion of **particles** increase.



Lesson Objectives

By the end of this lesson, you should be able to:

- Explain how the motion of molecules relates to pressure.
- List units of pressure and give values for standard **temperature** and pressure (STP).

Science Practice: Convert between units of pressure using **dimensional** analysis.



Words to Know

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

B pressure

C standard temperature and pressure (STP)

A barometer

A. a device for measuring pressure

B. the force exerted by the particles of a gas colliding with the walls of a container

C. the standard conditions used to compare gas measurements; defined as an absolute temperature of 273.15 K and a pressure of 100 kPa

Instruction

Pressure

Slide

1

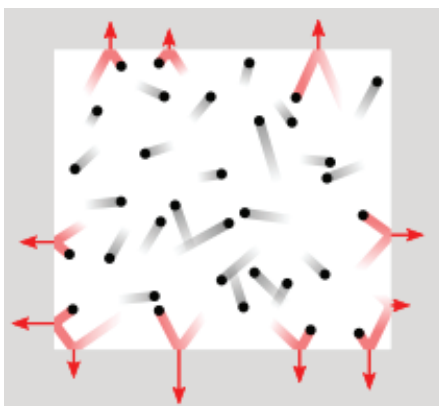
Lesson Question

What is pressure?

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Pressure

Pressure: the force exerted by the **particles** of a gas colliding with the **surface** of an object.



Pressure: the force exerted by the particles of a gas colliding with the surface of an object.

- Higher **kinetic** energy → greater collision force → higher pressure
- More collisions → greater collision force → **higher** pressure

Force (N)

Area (m²)

Pressure = $\frac{\text{Force (N)}}{\text{Surface Area (m}^2\text{)}}$

P = $\frac{F}{A}$ (N/m²)

The diagram shows five blue arrows pointing downwards from the top, representing force, towards a horizontal orange line representing a surface area. Below the surface area, the text defines pressure as force divided by surface area, and provides the formula P = F/A with units of N/m².

Instruction

Pressure

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Pressure, Particle Collisions, and Volume

More collisions → Greater collision **force** → Higher pressure

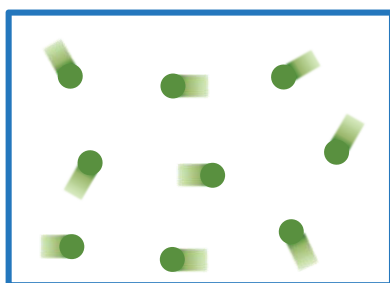
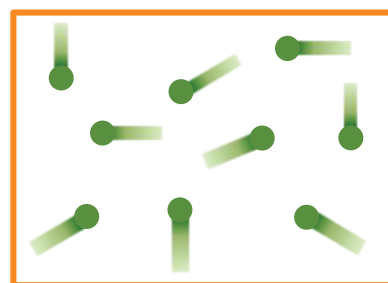
The water bottle on the left was sealed at an **altitude** of 14,000 feet.

At that altitude, atmospheric pressure is low because there are fewer **gas** particles in a given volume of **air** than there are at **sea** level.

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Temperature, Kinetic Energy, and Pressure

Higher kinetic energy → Greater **collision** force → Higher pressure

**Cooler****Warmer**

The temperature of an object depends only on the **average** kinetic energy of that **substance**.

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Measuring Pressure

Barometer: device used to measure atmospheric pressure

- Original barometers used mercury.
 - Dense
 - Low **evaporation** rate
- Modern barometers use small cells of air.
 - **Expansion** or **contraction** moves dial.

Units of Pressure

- SI unit: pascal (Pa)
 - $1 \text{ Pa} = 1 \text{ N/m}^2$
 - Common scientific units:
 - Millimeters of mercury (mmHg) or **torr**
 - Atmosphere (atm)
 - Kilopascal (kPa)
 - Other common units:
 - Pounds per square inch (psi)
 - **Bar**
 - Inches of **mercury** (inHg)
- Unit conversions:
- $1 \text{ atm} = \mathbf{760} \text{ mmHg}$
= 760 torr
 - $1 \text{ atm} = 101.325 \text{ kPa}$
= 101,325 Pa

Slide

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Converting between Pressure Units

The pressure inside a gas cylinder is 2,041 mmHg. How many atmospheres of pressure is the gas exerting on the cylinder?

- Identify the correct conversion factor.

- 760 mmHg = 1 atm

- Set up the dimensional analysis equation.

$$\frac{2041 \text{ mm Hg} \times 1 \text{ atm}}{760 \text{ mm Hg}} = ?$$

- Cancel units and solve.

$$\frac{2041 \text{ mm Hg} \times 1 \text{ atm}}{760 \text{ mm Hg}} = \text{2.686} \text{ atm}$$

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Converting between Pressure Units

Climbers on Mt. Everest must carry oxygen tanks with them because atmospheric pressure at the top of the mountain is so low they would be unable to breathe normally. If atmospheric pressure on the top of the mountain is 0.3333 atm, what is the pressure in kilopascals?

- Identify the correct conversion **factor**.

- 1 atm = 101.325 kPa

- Set up the **dimensional** analysis equation.

$$\frac{0.3333 \text{ atm Hg} \times 101.325 \text{ kPa}}{1 \text{ atm}} = ?$$

- Cancel units and solve.

$$\frac{0.3333 \text{ atm Hg} \times 101.325 \text{ kPa}}{1 \text{ atm}} = \mathbf{33.77} \text{ kPa}$$

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Standard Temperature and Pressure

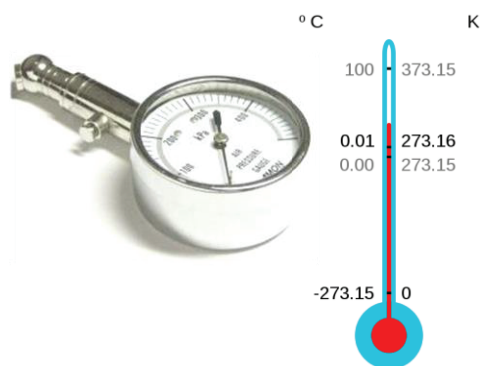
Standard temperature and pressure (STP):
standard conditions used to compare gas

measurements; defined as an **absolute**

temperature of 273.15 K and a pressure of 101.325 kPa (1 atm)

- Allows easy comparison of **gaseous** systems using constant conditions

- Must use **absolute** temperature in all gas calculations



Summary

Pressure

?

Lesson
Question

What is pressure?

✓

Answer

(Sample answer) Pressure is a type of force which is exerted by the particles of a gaseous substance which are colliding with the walls of the container or any other surface. A barometer is used to measure atmospheric pressure.

Slide

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Pressure

- Pressure is a measure of the **force** exerted on a given surface area.
- The pressure exerted by a gas on a surface is the result of the collisions of gas particles with the surface.
- Pressure increases if the number of collisions per unit area increases.
- Pressure increases if the force per **collision** increases.
- Pressure increases as **volume** decreases and as temperature and amount of **gas** increase.

Summary | Pressure

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Measuring and Describing Pressure

- **Barometers** are used to measure pressure.
- The SI unit for pressure is the **pascal** (Pa).
- Other common scientific units for pressure are millimeters of mercury (mmHg) or torr, atmospheres (atm), and kilopascals (kPa).
- Standard **temperature** and pressure is defined as 273.15 K and 101.325 kPa (1 atm).

Use this space to write any questions or thoughts about this lesson.