SCIENCE FOUNDATIONS

Gas laws

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how you explain why a car tire reads higher pressure on a hot afternoon, or why a spray can warns you never to heat it. A diver knows that air squeezed into a tank at depth takes up much less space than it does at the surface. A baker watches dough rise as warm gas expands inside it. Knowing gas laws tells you how pressure, volume, and temperature push each other around, so you can predict what a gas will do before you heat it, squeeze it, or let it expand.



Rule

Gas laws: Boyle's law, $P_1 \times V_1 = P_2 \times V_2$ at fixed temperature; Charles's law, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ at fixed pressure; and the combined gas law, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

Temperature must be in kelvin.

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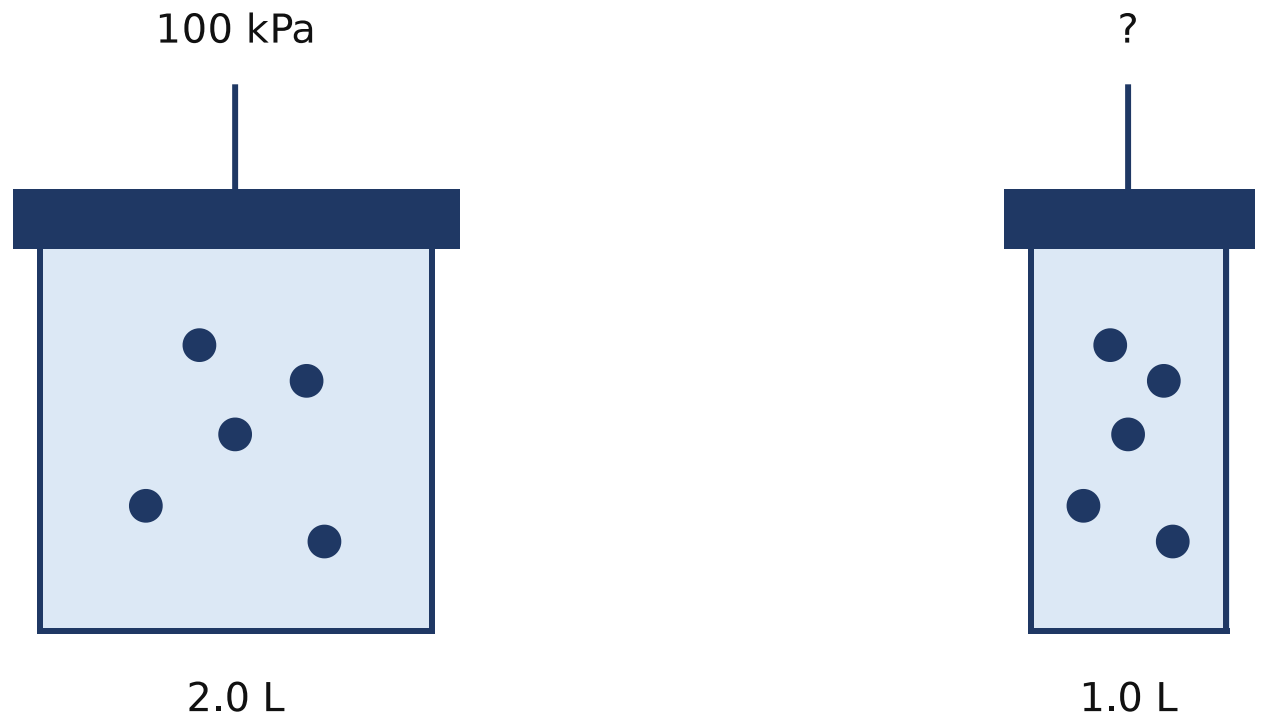
Worked examples

EXAMPLE 1

Q A gas at 100 kPa and 2.0 L is compressed to 1.0 L at fixed temperature. New pressure?



SOLUTION

Use Boyle:

$P_1 \times V_1 = P_2 \times V_2$

Substitute:

$100 \times 2.0 = P_2 \times 1.0$

Solve:

$P_2 = 200$ kPa

The result is 200 kPa.

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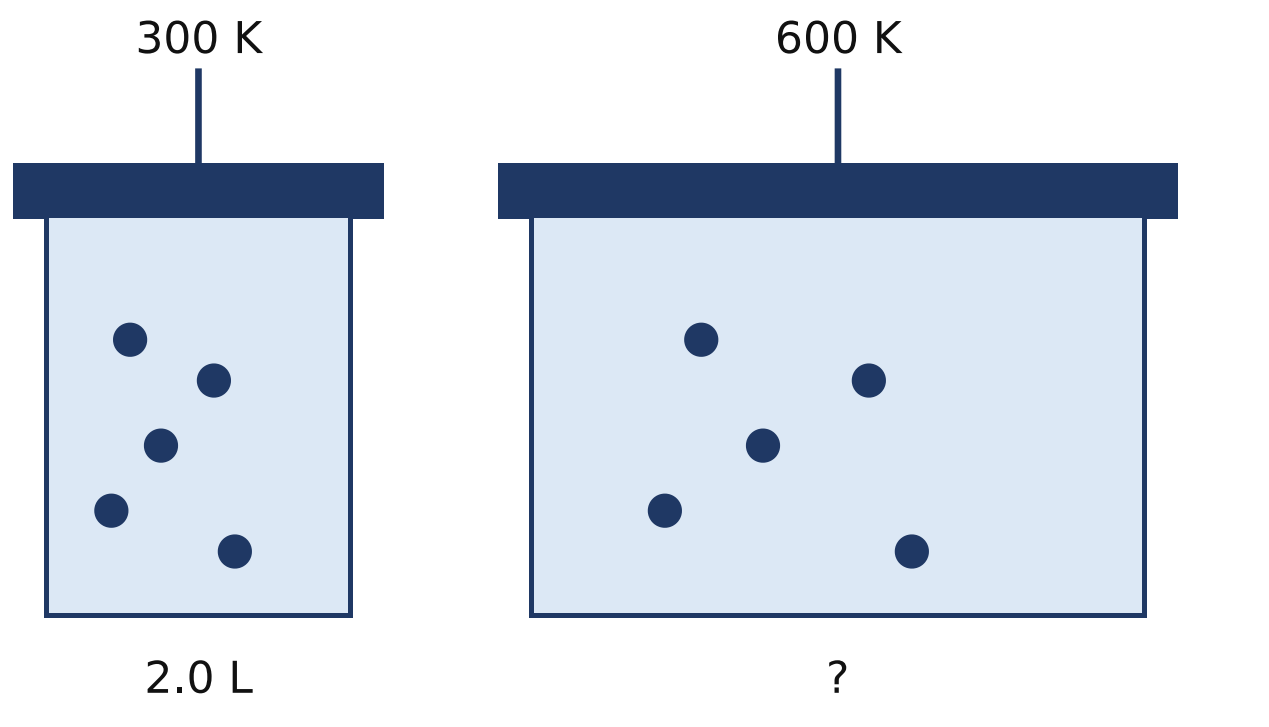
EXAMPLE 2

Q A gas at 300 K and 2.0 L is heated to 600 K at fixed pressure. New volume?



SOLUTION

Use Charles: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Substitute: $\frac{2.0}{300} = \frac{V_2}{600}$

Solve:

$V_2 = 4.0$ L

The result is 4.0 L.

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Practice questions

1 Boyle's law: what is constant?

- A Pressure times volume
- B Pressure divided by volume
- C Volume divided by pressure
- D Pressure plus volume

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2 Charles's law: what is constant?

- A Volume divided by temperature
- B Volume times temperature
- C Temperature divided by volume
- D Volume plus temperature

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150 kPa, 2.0 L compressed to 1.0 L: new pressure?

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4

300 K, 3.0 L heated to 600 K: new volume?

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5

Temperature must be in what unit?

A Kelvin

B Celsius

C Fahrenheit

D Joules

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6

If pressure doubles at fixed temperature, volume does what?

A Halves

B Doubles

C Stays the same

D Becomes zero

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7

If temperature doubles in kelvin at fixed pressure, volume does what?

A Doubles

B Halves

C Stays the same

D Becomes zero

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8 Combined gas law equation?

A $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

B P1V1 = P2V2

C $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

D $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

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9 Convert 27 degrees C to kelvin.

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10

A gas expands from 1.0 L to 2.0 L at fixed temperature. Pressure becomes?

A Half the original

B Double the original

C The same as before

D Zero

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ANSWER KEY

1. Pressure times volume

2. Volume divided by temperature

3. 300

4. 6.0

5. Kelvin

6. Halves

7. Doubles

8. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

9. 300

10. Half the original

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