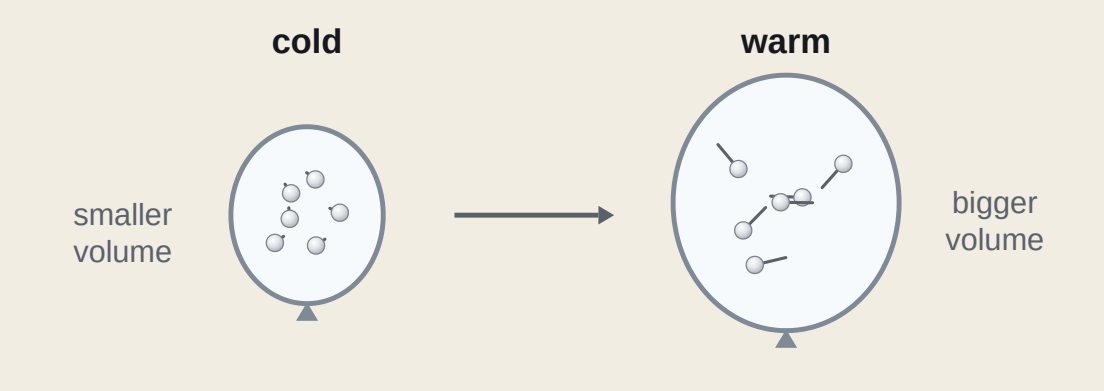
B4 · Charles's law: volume and temperature · Completed notes

Goals: Describe how the volume of a gas changes when its temperature changes. State Charles's law and the two things that must stay the same. Use Charles's law, with temperatures in kelvin, to find a volume or a temperature.

These are the completed notes. The blanks are filled in and each question is worked.

Slide 1 of 5 · Warming and cooling a gas

Lesson B3 linked pressure and volume. Now you keep the pressure the same and change the temperature.



Key ideas

Take a balloon outside on a cold day and it **shrinks**.

No air **leaked** out.

Warmer particles move **faster**.

Faster particles push the balloon skin out **further**.

Example

A balloon shrinks in the cold, but no air leaked out. Which of the four things we measure changed?

1. The amount of gas stayed the same.
2. The temperature went down, and then the volume went down.

Try it

Why does a balloon get bigger when the air inside it warms up?

1. Warmer particles move faster.
2. They push the balloon skin out further.

Slide 2 of 5 · Volume divided by kelvin temperature stays the same

On the last slide a balloon grew when it warmed. Measurements show exactly how much a gas grows.

temp. (°C)	temp. (K)	volume (L)	V ÷ T (L/K)
−73	200	2.00	0.0100
27	300	3.00	0.0100
127	400	4.00	0.0100

The amount of gas and the pressure stayed the same.

Key ideas

Change each temperature to kelvin: add **273**.

Divide each volume by its **kelvin temperature**.

Volume divided by kelvin temperature **stays the same**.

Example

A gas fills 3.00 L at 300 K and 6.00 L at 600 K. Divide each volume by its kelvin temperature. What do you notice?

1. 3.00 L ÷ 300 K = 0.0100 L/K.
2. 6.00 L ÷ 600 K = 0.0100 L/K.
3. The two answers are the same.

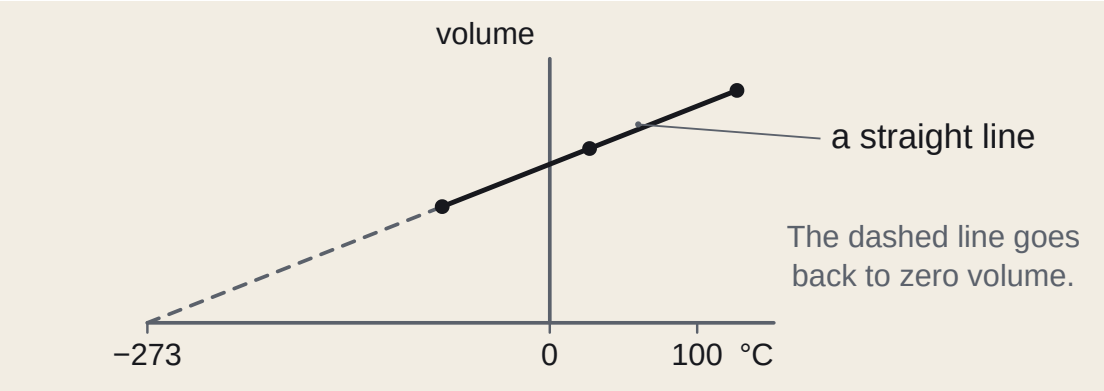
Try it

A table gives gas volumes with temperatures in degrees Celsius. What must you do before you divide?

1. Change each temperature to kelvin by adding 273.
2. Then divide each volume by its kelvin temperature.

Slide 3 of 5 · The graph for Charles's law

The last slide showed the results as a table. A graph shows the pattern, and something more.



Key ideas

The three dots lie on a **straight line**.

As the temperature goes up, the volume goes **up**.

Volume and temperature are **directly related**.

The dashed line reaches zero volume at **−273** °C.

Example

Draw the shape of the graph of volume against temperature for a gas. Say what the shape shows.

1. The graph is a straight line that rises.
2. It shows that volume goes up as temperature goes up.

Try it

The line on the graph is extended back to zero volume. What temperature does it reach?

1. It reaches −273 °C.
2. That is 0 K, absolute zero.

Slide 4 of 5 · Charles's law as a formula

The last two slides showed the pattern as a table and as a graph. Now you write it as a formula.

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

T is in kelvin, never in °C.

The pressure must stay the same.
The amount of gas must stay the same.

Key ideas

V_1 and T_1 are the volume and temperature **before** a change.

Both temperatures must be in **kelvin**.

Charles's law only works when the **pressure** and the amount of gas stay the same.

Both volumes must be in the **same unit**.

Example

Write Charles's law as a formula. Say what unit the temperatures must have.

1. $V_1/T_1 = V_2/T_2$.
2. Both temperatures must be in kelvin.

Try it

Name the two things that must stay the same for Charles's law to work.

1. The pressure of the gas must stay the same.
2. The amount of gas must stay the same.

Slide 5 of 5 · Using Charles's law

The last slide gave Charles's law as a formula. Now you use it to find a volume.

$T_1 = 15 + 273 = 288$ K, $T_2 = 75 + 273 = 348$ K

$V_1 = 3.60$ L, $V_2 = ?$

$V_2 = V_1T_2 / T_1$

$V_2 = (3.60 \text{ L} \times 348 \text{ K}) / 288 \text{ K}$

$V_2 = 4.35$ L

Key ideas

First change both temperatures to **kelvin**.

When the gas gets hotter, the volume goes **up**.

When the gas gets colder, the volume goes **down**.

Example

Use Charles's law, $V_1/T_1 = V_2/T_2$, and T (K) = t (°C) + 273. The pressure and the amount of gas do not change. A gas fills 2.00 L at 27 °C. It is heated to 87 °C. What is the new volume?

1. $T_1 = 27 + 273 = 300$ K and $T_2 = 87 + 273 = 360$ K.
2. $V_2 = V_1T_2 / T_1 = (2.00 \text{ L} \times 360 \text{ K}) / 300 \text{ K} = 2.40$ L.
3. The gas got hotter, so the volume went up.

Try it

Use Charles's law, $V_1/T_1 = V_2/T_2$, and T (K) = t (°C) + 273. The pressure and the amount of gas do not change. A gas fills 5.00 L at 47 °C. It is cooled to 7 °C. What is the new volume?

1. $T_1 = 47 + 273 = 320$ K and $T_2 = 7 + 273 = 280$ K.
2. $V_2 = V_1T_2 / T_1 = (5.00 \text{ L} \times 280 \text{ K}) / 320 \text{ K} = 4.38$ L.
3. The gas got colder, so the volume went down.