

Pressure in gases

4.3.3.2 · Particle model of matter · revision notes

What happens to the pressure of a gas when its volume changes at constant temperature. You need to explain this with the particle model and use $pV = \text{constant}$ (on the equation sheet). This subtopic is in GCSE Physics only, not in Combined Science. Expect particle explanations and 2 to 4 mark calculations, sometimes from a table of results.

Key facts

- $pV = \text{constant}$ (fixed mass of gas at constant temperature; on the equation sheet)
- $p_1V_1 = p_2V_2$
- Bigger volume $\rightarrow$ molecules collide with the walls less often $\rightarrow$ lower pressure
- p in Pa, V in m^3 ; 1 kPa = 1000 Pa
- Volume up $\rightarrow$ pressure down (at constant temperature)
- Gas pressure produces a net force at right angles to any surface

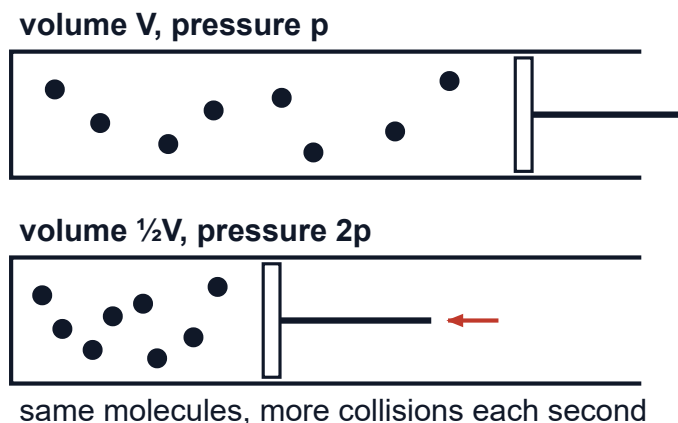
Notes

Gas pressure and force

- A gas can be **compressed** (squashed into a smaller volume) or **expanded** by changes in pressure.
- The pressure of a gas produces a **net force at right angles** to the wall of its container, or to any surface the gas touches.
- That is why the air in a balloon pushes outwards on every part of the rubber.

Changing the volume at constant temperature

- For a **fixed mass** of gas at a **constant temperature**, increasing the volume decreases the pressure.
- Why: the molecules have more space, so they travel further between collisions with the walls. They collide with the walls **less often**, so there is a smaller force on each unit area: the pressure is lower.
- The temperature is constant, so the average kinetic energy (and speed) of the molecules does not change. It is the frequency of the collisions that changes.
- Decreasing the volume does the opposite: the molecules collide with the walls more often, so the pressure increases.



Constant temperature: smaller volume, more frequent collisions, higher pressure.

$pV = \text{constant}$

- For a fixed mass of gas at constant temperature: pressure $\times$ volume = constant, **$pV = \text{constant}$** (on the equation sheet). p in pascals (Pa), V in m^3 .
- To compare two situations use **$p_1V_1 = p_2V_2$** . Any units work, as long as both pressures are in the same unit and both volumes are in the same unit.
- Pressure and volume are **inversely proportional**: halve the volume and the pressure doubles; triple the volume and the pressure falls to a third.

How to answer each type of question

Recall: the force from a gas and the effect of volume

1 mark each

Grade 5

- The force from gas pressure is always at right angles (perpendicular) to the surface.
- At constant temperature, pressure $\times$ volume stays the same: if one doubles, the other halves.

Example. A fixed mass of gas is held in a closed container.

- Describe the direction of the force that the gas exerts on the walls of the container.
- The volume of the container is doubled and the temperature of the gas does not change. What happens to the pressure of the gas?

Model answer. (a) At right angles (perpendicular) to the walls (1)

(b) The pressure halves (1)

Don't lose marks

- ✗ Using $pV = \text{constant}$ when the temperature changes. It needs a fixed mass of gas at constant temperature.
- ✗ Mixing units, e.g. one pressure in kPa and the other in Pa.
- ✗ Saying the molecules hit the walls 'with less force' when the volume increases. At constant temperature their speed is unchanged; they hit the walls less often.
- ✗ Rearranging the wrong way up: $p_2 = p_1V_1 \div V_2$, not $p_1V_2 \div V_1$. Use the sense check.
- ✗ Saying gas pressure acts 'downwards' or 'along' a wall. It acts at right angles to the surface.

More tips

Memory tricks

- Squash a gas and its pressure goes up: halve V , double p .
- Units shortcut: for $p_1V_1 = p_2V_2$ you don't need Pa and m^3 ; just use the same units on both sides.
- Sense check: if the volume got smaller, the new pressure must be bigger (and the other way round).
- To test data, multiply $p \times V$ for every row: the products should all be about the same.

Exam technique

- $pV = \text{constant}$ is on the equation sheet. Write $p_1V_1 = p_2V_2$ with the numbers substituted to earn the first mark.
- In particle explanations for a volume change at constant temperature, the key phrase is 'collide with the walls less (or more) frequently'.
- If a question says a gas was compressed or expanded slowly, that tells you its temperature stayed constant.
- Give the unit of your answer: it is the unit you used for that quantity (e.g. kPa or cm^3).

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

State the direction of gas pressure forces

The pressure of a gas produces a net force at right angles to the wall of its container (or any surface).

Grade 5

Describe how volume affects gas pressure

At constant temperature, increasing the volume of a gas decreases its pressure, and decreasing the volume increases it.

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