Particle motion in gases

4.3.3.1 · Particle model of matter · revision notes

How the random motion of gas molecules explains the temperature and pressure of a gas. You need to link the temperature of a gas to the average kinetic energy of its molecules, and explain in words (no calculations) why heating a gas in a fixed volume increases its pressure. Questions are mainly 2 to 4 mark explanations in contexts such as tyres, aerosol cans and sealed containers.

Key facts

- Gas molecules are in constant random motion
- Gas pressure is caused by molecules colliding with the walls and exerting a force on them
- Hotter → molecules faster → collide with the walls more often and with more force
- Higher temperature = greater average kinetic energy of the molecules
- Constant volume: temperature up → pressure up
- Cooler → molecules slower → fewer, weaker collisions with the walls → lower pressure

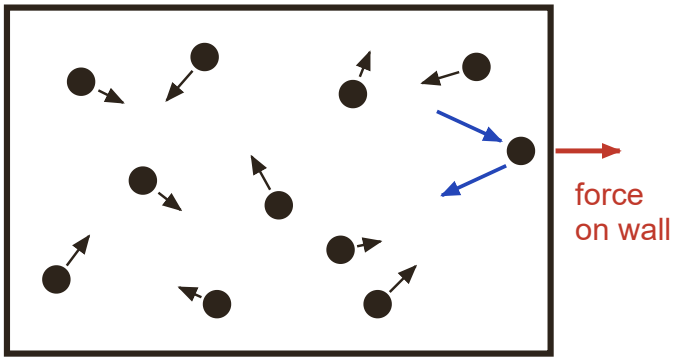
Notes

Gas molecules and temperature

- The molecules of a gas are in **constant random motion**. They move in all directions, at a range of speeds, and keep colliding with each other and with the walls of their container.
- The **temperature** of a gas is related to the **average kinetic energy** of its molecules.
- Heating a gas raises its temperature, so its molecules move faster on average. Cooling a gas slows its molecules down.

How a gas exerts pressure

- Gas molecules constantly collide with the walls of their container.
- In each collision, a molecule exerts a force on the wall. Huge numbers of molecules collide every second, so together they produce a steady force on the wall.
- The **pressure** of the gas is the force that these collisions produce on each unit of area of the wall.

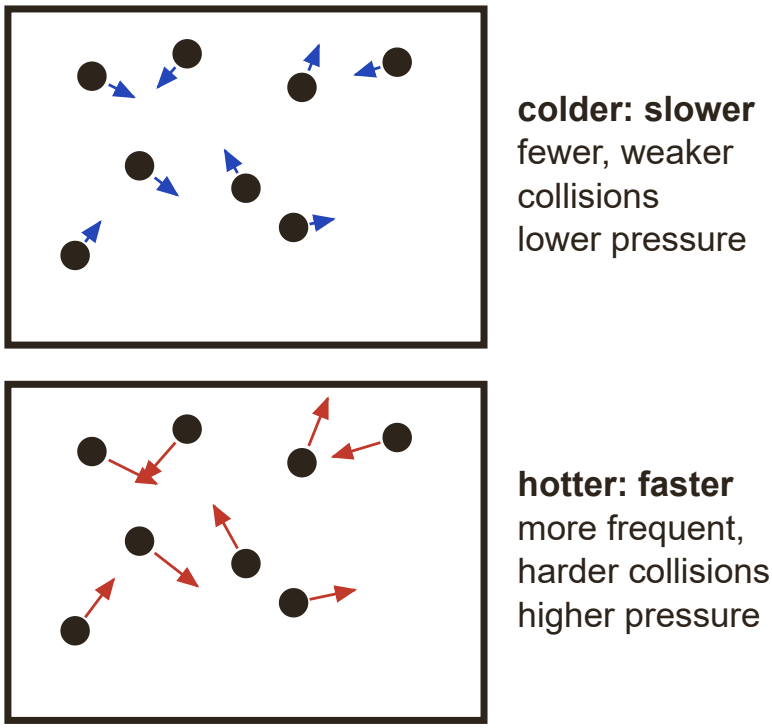


random motion: all directions, a range of speeds

Each collision pushes on the wall. Force per unit area = pressure.

Heating a gas at constant volume

- If a gas is in a sealed container that cannot expand (constant volume), increasing its temperature increases its pressure.
- Why: the molecules gain kinetic energy and move faster on average, so they **collide with the walls more often** (more collisions each second) and **with more force** in each collision. Both effects increase the pressure.



Same volume, higher temperature: faster molecules, higher pressure.

- Cooling the gas does the opposite: the molecules move more slowly, so they hit the walls less often and with less force, and the pressure falls.
- Examples: a sealed aerosol can may burst if it is heated; car tyre pressure rises after a long drive because the air inside warms up.

How to answer each type of question

Describe the motion of gas molecules 1 to 2 marks **Grade 3**

1. Use the key words: constant (never stops) and random (all directions).
2. If the question mentions temperature, link it to the average kinetic energy (speed) of the molecules.

Example. Describe the motion of the molecules in a gas. (2 marks)

Model answer. The molecules move all the time / constantly (1) in random directions (1).

Explain how a gas exerts a pressure 2 marks **Grade 5**

1. Say that the molecules collide with the walls (surface).
2. Say that each collision exerts a force, and the force on each unit area is the pressure.

Example. A balloon is filled with air.
Explain how the air molecules exert a pressure on the inside of the balloon.

Model answer. The air molecules collide with the inside surface of the balloon (1). Each collision exerts a force on the surface; the total force on each unit area is the pressure (1).

Explain why heating a gas at constant volume increases its pressure 3 to 4 marks **Grade 5**

1. Link the temperature rise to the kinetic energy (speed) of the molecules.
2. Say that the molecules collide with the walls more often (more frequently).
3. Say that each collision exerts a greater force.
4. Conclude: so the pressure increases.

Example. A sealed metal can of air is placed in hot water, which increases the temperature of the air inside. The volume of the can does not change.
Explain, in terms of particles, why the pressure of the air in the can increases. (3 marks)

Model answer. The air molecules gain kinetic energy / move faster on average (1). So they collide with the walls of the can more frequently (1) and with a greater force in each collision, so the pressure increases (1).

Predict and explain a pressure change in a context 3 marks **Grade 5**

1. Decide whether the gas gets hotter or colder, and check that its volume stays (roughly) the same.
2. State the effect on the pressure.
3. Explain it with the speed of the molecules and both the frequency and the force of their collisions with the walls.

Example. A car is left outside on a very cold night. Explain what happens to the pressure of the air in its tyres. Assume that the volume of the tyres does not change.

Model answer. The pressure decreases (1). The air cools, so its molecules have less kinetic energy / move more slowly on average (1). So they collide with the walls of the tyre less often and with less force (1).

Don’t lose marks

- ✕ Saying the molecules get bigger or expand when heated. They move faster; their size does not change.
- ✕ Giving only one effect. Say the molecules hit the walls more often AND with more force.

- ✗ Saying the pressure rises because the molecules collide with each other more. Pressure comes from collisions with the walls.
- ✗ Writing just 'more collisions'. Say 'more collisions per second' or 'collide more frequently'.
- ✗ Saying the molecules have 'more energy' without saying which kind: say kinetic energy.
- ✗ Writing that heated gas molecules 'vibrate more'. Mark schemes reject this: they move faster (greater average speed).

More tips

Memory tricks

- Pressure chain: hotter → faster molecules → hit the walls more often AND harder → higher pressure.
- Constant volume + hotter = higher pressure. That is why aerosol cans warn you not to heat them.
- Temperature = average kinetic energy, so 'hotter gas' always means 'faster molecules on average'.

Exam technique

- Use the key phrases: 'constant random motion', 'average kinetic energy', 'collide with the walls more frequently', 'with greater force'.
- Check what is held constant: these explanations are for a gas whose volume does not change.
- In 3-mark explanations, build a chain: temperature → kinetic energy (speed) → collisions with the walls (frequency and force) → pressure.

What each grade needs

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

Grade 3 — **Describe the motion of gas molecules**
They are in constant random motion, moving in all directions.

Grade 4 — **Link gas temperature to molecules' kinetic energy**
The higher the temperature, the greater the average kinetic energy of the molecules, so the faster they move on average.

Grade 5 — **Explain how a gas exerts pressure**
Molecules collide with the walls of the container and exert a force on them; the force on each unit area is the pressure.

Grade 5 — **Explain pressure rise when heated at constant volume**
Faster molecules collide with the walls more often and with more force, so the pressure increases.

Grade 5 — **Apply the particle model to real situations**
For example, explain why a sealed can may burst if heated, or why tyre pressure falls on a cold night.

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