

How particles explain solids, liquids and gases

Grade 7 science (Year 8 · Class 7) · Lesson

Quick answer: The particle model says that all matter is made of tiny particles that are always moving. In solids the particles vibrate in fixed positions, in liquids they slide past each other, and in gases they move freely far apart. This one idea explains shape, volume, compression, diffusion and changes of state.

Level: Grade 7 science (Year 8 · Class 7) · **Curriculum:** MS-PS1-1, MS-PS1-4

What is the particle model of matter?

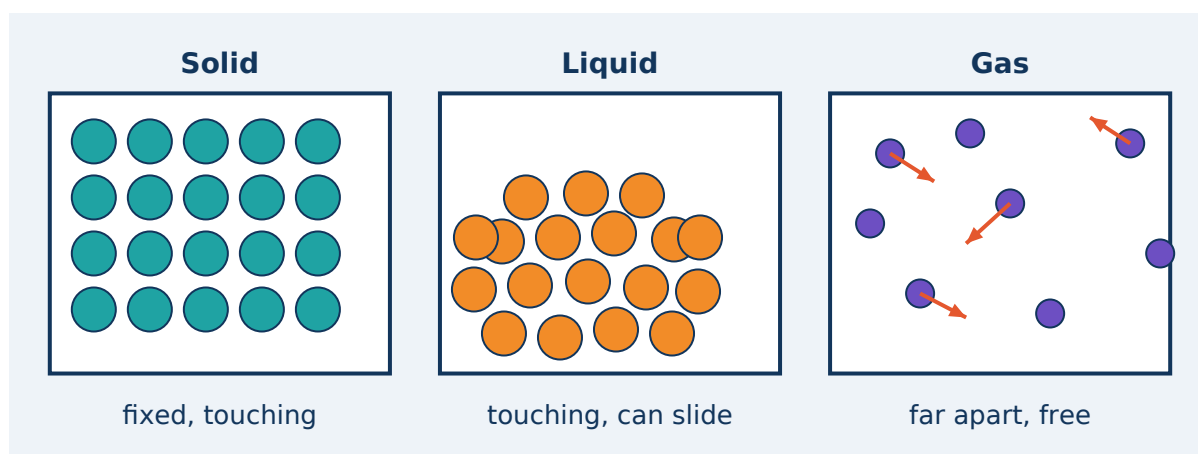
Everything around you, from a cricket ball to the air inside it, is matter. Matter looks smooth, but scientists picture it as a huge number of tiny particles. The particle model is a simple picture that uses this idea to explain what we observe.

Definition

The **particle model** says that all matter is made of very small particles, that the particles are always moving, and that there are forces of attraction between them. The particles themselves are not hot, soft or coloured; they are just the building blocks.

How are particles arranged in solids, liquids and gases?

The three states of matter differ in how close the particles are, how they move and how strongly they hold on to each other. The figure shows the three arrangements, and the table compares what you can observe with what the particles do.



Particle diagrams of a solid, a liquid and a gas. Red arrows show that gas particles travel in straight lines until they collide.

State	Particle arrangement	Particle movement	Shape and volume
Solid	Packed closely in a regular pattern	Vibrate about fixed positions	Fixed shape, fixed volume
Liquid	Close together in a random jumble	Slide past one another	Takes the shape of its container, fixed volume
Gas	Far apart, no pattern	Move fast in all directions	Fills its container, no fixed volume

In a solid the attraction between particles is strong enough to hold each one in place. In a liquid it is weaker, so particles can swap neighbours. In a gas it is almost zero, so particles fly apart and spread out.

Key rule

The stronger the attraction between particles compared with their movement, the more rigid the state. Solids are rigid, liquids flow, gases spread out.

Why can a gas be squashed but a solid or a liquid cannot?

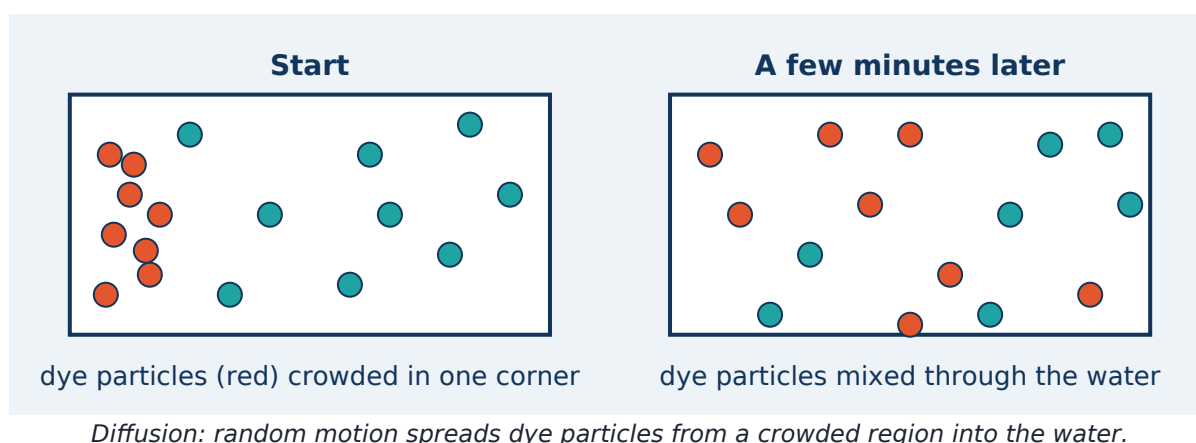
Gas particles are far apart, so most of a gas is empty space. Pushing on a bicycle pump moves the particles closer together without changing the particles. Particles in solids and liquids already touch, so there is almost no room to squeeze them. Gas pressure comes from particles hitting the walls of their container: more hits every second means higher pressure.

What is diffusion?

Particles in liquids and gases move at random. They bump into each other and change direction, so over time they spread from places where they are crowded to places where there are fewer of them. This spreading is called diffusion.

Definition

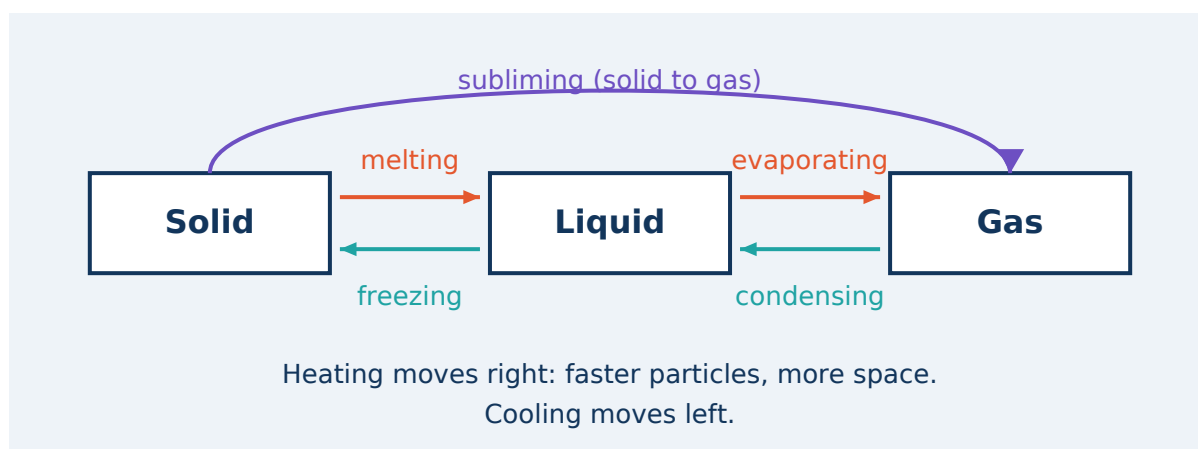
Diffusion is the net movement of particles from a region where they are more concentrated to a region where they are less concentrated, caused by their random motion.



Diffusion is why the smell of frying onions reaches the next room. It is faster in gases than in liquids because gas particles move more freely, and faster in warm substances because warm particles move more quickly. It does not happen in solids in any noticeable way, because the particles cannot leave their positions.

What happens to particles during a change of state?

When a solid is heated, its particles vibrate more strongly. At the melting point they can break free from their fixed positions and the solid turns into a liquid. Further heating makes particles move faster until, at the boiling point, they escape from the liquid as a gas. Cooling reverses the sequence. The particles stay the same during all this: only their spacing, speed and arrangement change.



Names of the changes of state. Heating pushes matter to the right, cooling to the left.

Worked example 1

Aarav in Pune notices that sugar crystals keep their shape but tea takes the shape of the cup. **Explain this using particles.** Sugar crystals are solid, so their particles are held in fixed positions in a regular pattern and cannot move past one another. Tea is a liquid, so its particles are close but can slide, and the tea flows to fill the bottom of the cup.

Answer: solid particles are fixed in place, liquid particles can slide.

Worked example 2

Mei in Singapore places one drop of ink in warm water and one in cold water, without stirring. The ink spreads 3.0 cm in 60 s in warm water and 3.0 cm in 150 s in cold water.

Compare the average speeds. Speed = distance ÷ time. Warm: $3.0 \text{ cm} \div 60 \text{ s} = 0.050 \text{ cm/s}$. Cold: $3.0 \text{ cm} \div 150 \text{ s} = 0.020 \text{ cm/s}$. Ratio: $0.050 \div 0.020 = 2.5$. **Answer: the ink spreads 2.5 times faster in warm water because warm particles move faster.**

Common mistake

Do not say that particles themselves melt, expand or get hotter when a substance is heated. The particles stay the same size and keep their mass. What changes is how fast they move and how far apart they are.

Lina's tip

Draw three little boxes before you answer any state question: tightly packed circles, touching circles in a jumble, and a few lonely circles. Then match your answer to the box.

Key points to remember

- Matter is made of tiny particles in constant motion.
- Solid: particles touch and vibrate in fixed positions; liquid: touch and slide; gas: far apart and free.
- Diffusion is the spreading of particles from a crowded region to a less crowded one.
- Particles keep their size when heated; only speed and spacing change.
- Gas pressure comes from particles hitting the container walls.

How particles explain solids, liquids and gases: frequently asked questions

What are the main ideas of the particle model?

All matter is made of tiny particles. The particles are always moving, and the faster they move the higher the temperature. There are forces of attraction between particles, and between them there is empty space.

Why do liquids flow but solids do not?

In a liquid the particles are close together but can slide past each other, so the liquid flows. In a solid every particle is held in a fixed position and can only vibrate.

What is diffusion in simple words?

Diffusion is the spreading out of particles from a crowded place to a less crowded place. It happens because particles move randomly and collide, and it is quickest in warm gases.

Does the size of particles change when a substance is heated?

No. The particles stay the same size. Heating makes them move faster, and in a solid or liquid this usually pushes them slightly further apart, so the whole sample expands.

What is the difference between evaporating and boiling?

Evaporation happens at the surface of a liquid at any temperature, when fast particles escape. Boiling happens throughout the liquid at its boiling point, where bubbles of gas form inside it.