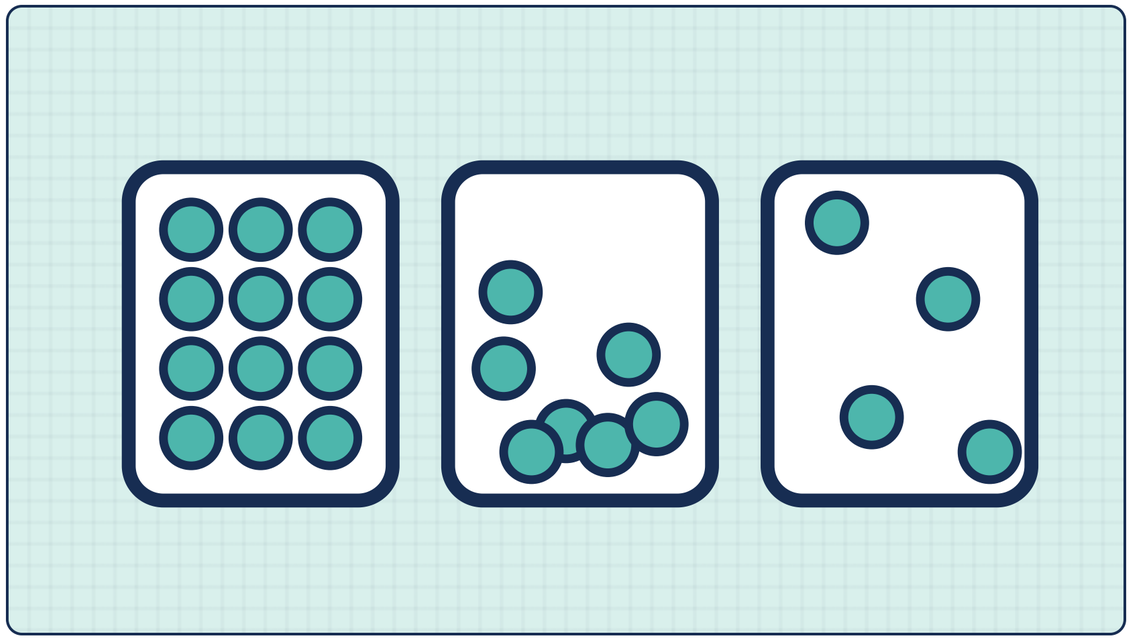
Science · Solids, liquids, gases and the particle model

States of Matter



Goals

By the end of this lesson you can

- Describe particles in solids, liquids and gases
- Explain properties using the particle model
- Name the changes of state
- Tell evaporation from boiling
- Explain gas pressure and diffusion

Everything is made of particles

- Matter is anything that has mass and takes up space
- All matter is made of tiny particles: atoms or molecules
- The particles are always moving
- Attractions between particles pull them together

Solids

- Fixed shape and fixed volume
- Particles tightly packed, often in a regular pattern
- Particles vibrate about fixed positions
- Cannot flow and are very hard to squash

Liquids

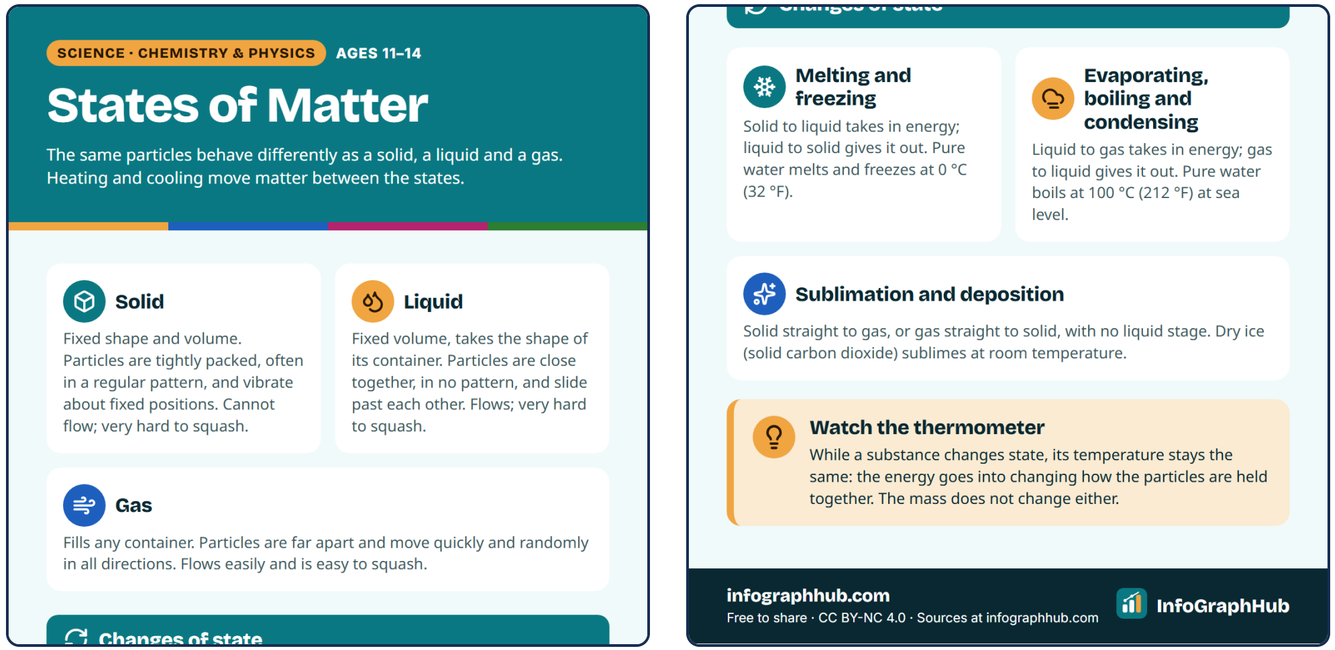
- Fixed volume, but take the shape of their container
- Particles close together with no regular pattern
- Particles move past each other but stay in contact
- Can flow, but are very hard to squash

Gases

- No fixed shape or volume: they fill any container
- Particles far apart with no regular pattern
- Particles move quickly and randomly in all directions
- Flow easily and are easy to squash

Solids, liquids and gases compared

- Same particles, different spacing and movement
- Changes of state move between the three



Poster: States of Matter: Solids, Liquids and Gases in the Particle Model

What decides the state?

- Attractions between particles pull them together
- Movement energy lets particles break away
- Strong attractions, little energy: solid
- More energy than the attractions can hold: gas

Changes of state

- Melting: solid to liquid; freezing: liquid to solid
- Evaporating or boiling: liquid to gas
- Condensing: gas to liquid
- Sublimation: solid straight to gas, as with dry ice
- Deposition: gas straight to solid

Energy in, energy out

- Melting, boiling and sublimation take in energy
- Freezing, condensing and deposition give out energy
- During a change of state, the temperature stays the same
- The energy goes into changing how particles are held together

Water's fixed points

0 °C · 100 °C

pure water freezes at 0 °C (32 °F) and

boils at 100 °C (212 °F) at sea level

- Lower air pressure means a lower boiling point
- In Leadville, Colorado (US), water boils at about 90 °C

Evaporation vs boiling

Evaporation

- Happens at any temperature
- Only at the surface of the liquid
- Only the fastest particles escape
- Slow and quiet, like a puddle drying

Boiling

- Happens only at the boiling point
- Throughout the whole liquid
- Particles across the liquid escape
- Fast, with bubbles of vapour

Gas pressure and diffusion

- Gas particles hit the walls of their container
- These collisions push on the walls: that is gas pressure
- Heating makes particles faster, so they hit harder and more often
- Diffusion: particles spread from where there are many to where there are few

Worked example

a kettle and a cold window

- Water is heated in a kettle until it boils
- Water particles leave the liquid as an invisible gas
- The gas reaches a cold window and loses energy
- It condenses back into liquid droplets on the glass

Common mix-ups

- Particles do not melt, expand or change size
- Only the spacing and movement of particles change
- There is empty space, not air, between gas particles
- Mass stays the same when a substance changes state

Quick check

Why can a gas be squashed into a smaller volume but a liquid cannot?

A. Gas particles are smaller

B. Gas particles are far apart with space between them

C. Liquid particles do not move

D. Gases have no mass

Summary

Key takeaways

1. All matter is made of moving particles
2. Solids vibrate in place; liquids slide past; gases move freely
3. Changes of state take in or give out energy
4. Temperature stays constant during a change of state
5. Gas pressure comes from particles hitting surfaces