Changes of state

4.3.1.2 · Particle model of matter · revision notes

Naming the changes of state, describing what happens to the particles, and knowing that mass is conserved because a change of state is a physical change. Questions are usually short recall and 2 to 4 mark explanations, often linked to particle diagrams or heating and cooling graphs.

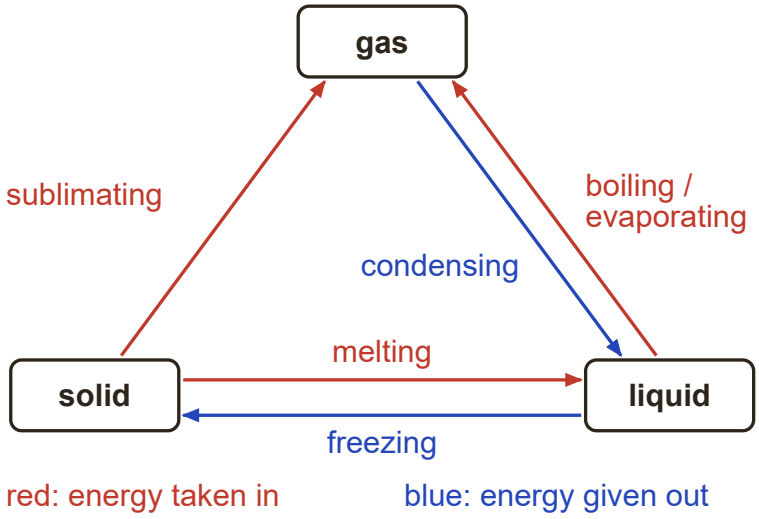
Key facts

- Melting: solid → liquid; freezing: liquid → solid
- Boiling or evaporating: liquid → gas; condensing: gas → liquid
- Sublimating: solid → gas directly
- Mass is conserved in a change of state (same number of particles)
- Change of state = physical change: reversible, and the material recovers its original properties
- Chemical change: a new substance is formed
- Volume and density change in a change of state; mass does not
- Boiling: throughout the liquid, at the boiling point. Evaporation: at the surface, also below the boiling point

Notes

Naming the changes of state

- **Melting**: solid → liquid. **Freezing**: liquid → solid.
- **Boiling** and **evaporating**: liquid → gas. Boiling happens throughout the liquid at its boiling point; evaporation happens only at the surface and can happen at temperatures below the boiling point.
- **Condensing**: gas → liquid.
- **Sublimating**: solid → gas directly, without becoming a liquid first. Example: solid carbon dioxide (dry ice).



The changes of state. Mass is conserved in every one.

- A pure substance melts (and freezes) at a fixed temperature, its melting point, and boils at a fixed temperature, its boiling point.

What happens to the particles

- Melting: energy supplied overcomes some of the forces holding the particles in fixed positions. They can now move past each other, but they stay close together.
- Boiling: energy supplied overcomes the forces between the particles, so they move far apart and move quickly in all directions.
- Condensing and freezing are the reverse: energy is transferred to the surroundings as the forces between the particles pull them together. On condensing they move close together; on freezing they settle into a regular arrangement, vibrating about fixed positions.
- The particles themselves do not change. Only their arrangement, spacing and motion change.

Mass is conserved: a physical change

- When a substance changes state, its **mass is conserved**, because the number of particles stays the same.
- The volume usually changes (the particles move closer together or further apart), so the density changes, but the mass does not.
- A change of state is a **physical change**: if you reverse it, the material recovers its original properties. Ice that melts and then refreezes is still ice, made of the same water molecules.
- In a **chemical change** a new substance is made (e.g. when fuel burns), and reversing the conditions does not give you the original material back.
- If a liquid evaporates or boils in an open container, the mass of the container and its contents falls because particles escape into the air. Mass is still conserved: the missing mass is now in the air as gas.

How to answer each type of question

Name the change of state 1 mark each **Grade 3**

1. Identify the starting state and the final state.
2. Use the exact term: melting, freezing, boiling (or evaporating), condensing or sublimating.

Example. Name the change of state in each case.
(a) Water vapour forms droplets on a cold window.
(b) A block of solid carbon dioxide turns straight into a gas.
(c) Molten wax in a mould becomes solid.

Model answer.

(a) Condensing (1)
(b) Sublimating (1)
(c) Freezing (1)

State and explain what happens to the mass 2 marks **Grade 4**

1. State clearly what happens to the mass: it stays the same.
2. Give the reason: the number of particles does not change (no particles are added or removed).

Example. A student seals 40 g of ice in a plastic bag and leaves it until all the ice has melted. State the mass of water in the bag. Give a reason for your answer.

Model answer. 40 g (1). No particles can enter or leave the sealed bag, so the number of particles stays the same and mass is conserved (1).

Explain why a change of state is a physical change 2 marks **Grade 5**

1. Say that no new substance is formed.
2. Say that the change can be reversed and the material recovers its original properties.

Example. Candle wax can be melted and then left to cool until it is solid again.
Explain why melting wax is a physical change and not a chemical change.

Model answer. No new substance is formed when the wax melts (1). When the wax cools and freezes, it recovers its original properties, so the change is reversible (1).

Describe how the particles change 3 marks **Grade 5**

1. Describe the particles before the change: arrangement, spacing and motion.
2. Describe what is different after the change.
3. Use comparisons: 'regular' and 'random', 'fixed positions' and 'move past each other'.

Example. Describe how the arrangement and motion of the particles change when a solid melts to form a liquid.

Model answer.

Any three from:

in the solid, the particles are in a regular arrangement	(1)
in the solid, the particles vibrate about fixed positions	(1)
in the liquid, the arrangement is random	(1)
in the liquid, the particles can move past each other	(1)
the particles stay close together	(1)

Explain an apparent change in mass 2 marks **Grade 6**

1. Say where the particles went (or came from): into or out of the air.
2. Say that the total mass, including the gas, is unchanged.

Example. A student boils some water in an open beaker for 5 minutes. The mass of the beaker and water decreases by 12 g.
Explain why this does not mean that mass is lost when water changes state.

Model answer. Some of the water particles turned into steam and escaped into the air (1). The steam has a mass of 12 g, so the total mass of the water plus the steam is unchanged (1).

Don’t lose marks

- Saying the mass changes when ice melts because the volume changes. The volume and density change; the mass does not.

- Mixing up condensing (gas → liquid) and evaporating (liquid → gas).
- Writing that the particles expand, melt or get bigger. Only their arrangement, spacing and motion change.
- Saying a change of state is physical 'because it is reversible' without saying that no new substance forms or that the material recovers its original properties.
- Treating boiling and evaporating as identical: evaporation happens at the surface, also at temperatures below the boiling point.

More tips

Memory tricks

- Sublimation skips a step: solid → gas without passing through the liquid state.
- Physical change = same substance, different state. Chemical change = new substance.
- Sealed container: mass stays the same. Open container: mass can seem to change as particles escape into the air or join from it.
- Opposite pairs: melting ↔ freezing, boiling or evaporating ↔ condensing.

Exam technique

- Use the exact names of the changes of state; phrases such as 'turns into vapour' may not get the mark.
- For conservation of mass, always give the particle reason: the number of particles stays the same.
- When describing particles, cover arrangement (regular or random), spacing (close or far apart) and motion (vibrate, move past each other, move quickly in all directions).
- If a question mentions an open container, think about particles escaping into, or coming from, the air.

What each grade needs

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

Grade 3 — **Name the changes of state**
Melting, freezing, boiling, evaporating, condensing and sublimating.

Grade 4 — **State that mass is conserved**
When a substance changes state the number of particles stays the same, so its mass does not change.

Grade 5 — **Describe particle changes during melting and boiling**
Describe how the arrangement, spacing and motion of the particles change.

Grade 5 — **Explain why a change of state is physical**
No new substance is made: if the change is reversed, the material recovers its original properties.

Grade 6 — **Explain why density changes but mass does not**
The particles move closer together or further apart, so the volume changes but the number of particles does not.

Grade 6 — **Explain mass changes in an open container**
Particles can escape into the air, so the container's mass drops even though the total mass is conserved.

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