

Chapter 6: Molecules and matter

Knowledge organiser

Changes of state

Changes of state and conservation of mass

Changes of state are physical changes because no new substances are produced. The mass always stays the same because the number of particles does not change.

Particles and kinetic energy

When the temperature of a substance is increased, the kinetic energy store of its particles increases and the particles vibrate or move faster.

If the kinetic store of a substance's particles increases or decreases enough, the substance may change state.

Density

You can calculate the density of an object if you know its mass and volume:

$$\text{density (kg/m}^3\text{)} = \frac{\text{mass (kg)}}{\text{volume (m}^3\text{)}}$$

$$\rho = \frac{m}{V}$$

Internal energy

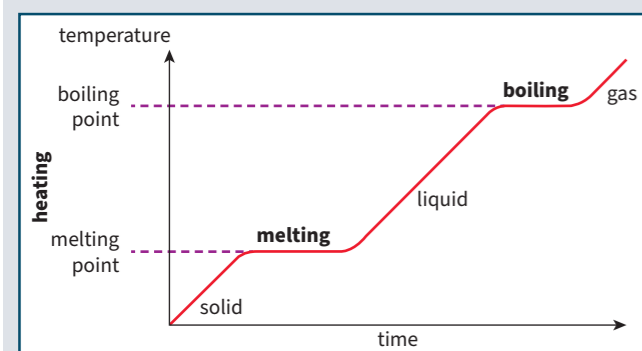
Heating a substance increases its **internal energy**.

Internal energy is the sum of the total kinetic energy the particles have due to their motion and the total potential energy the particles have due to their positions relative to each other.

Latent heat

In a graph showing the change in temperature of a substance being heated or cooled, the flat horizontal sections show when the substance is changing state.

The energy transfers taking place during a change in state do not cause a change in temperature, but do change the internal energy of the substance.



States of matter

Gas	Arrangement	<ul style="list-style-type: none"> particles are spread out almost no forces of attraction between particles large distance between particles on average
	Movement	<ul style="list-style-type: none"> particles move randomly at high speed
	Properties	<ul style="list-style-type: none"> low density no fixed volume or shape can be compressed and can flow spread out to fill all available space

Liquid	Arrangement	<ul style="list-style-type: none"> particles are in contact with each other forces of attraction between particles are weaker than in solids
	Movement	<ul style="list-style-type: none"> particles are free to move randomly around each other
	Properties	<ul style="list-style-type: none"> usually lower density than solids fixed volume shape is not fixed so they can flow

Solid	Arrangement	<ul style="list-style-type: none"> particles held next to each other in fixed positions by strong forces of attraction
	Movement	<ul style="list-style-type: none"> particles vibrate about fixed positions
	Properties	<ul style="list-style-type: none"> high density fixed volume fixed shape (unless deformed by an external force)

The energy transferred when a substance changes state is called the **latent heat**.

Specific latent heat – the energy required to change 1 kg of a substance with no change in temperature.

Specific latent heat of fusion – the energy required to melt 1 kg of a substance with no change in temperature.

Specific latent heat of vaporisation – the energy required to evaporate 1 kg of a substance with no change in temperature.

The energy needed to change the state of a substance can be calculated using the equation:

$$\text{thermal energy for a change in state (J)} = \text{mass (kg)} \times \text{specific latent heat (J/kg)}$$

$$E = m \times l$$

The relationship between temperature and pressure in gases

Gas temperature

The particles in a gas are constantly moving in random directions and with random speeds. The temperature of a gas is related to the average kinetic energy of its particles. When a gas is heated, the particles gain kinetic energy and move faster, so the temperature of the gas increases.

If the temperature of a gas in a sealed container is increased, the pressure increases because

- the particles move faster so they hit the surfaces with more force
- the number of these impacts per second increases, exerting more force overall.

Gas pressure

The pressure a gas exerts on a surface, such as the walls of a container, is caused by the force of the gas particles hitting the surface. The pressure of a gas produces a net force at right angles to the walls of a container or any surface.

If a gas is compressed quickly, for example, in a bicycle pump, its temperature can rise. This is because

- compressing the gas requires a force to be applied to the gas – this results in work being done to the gas, since work done = force × distance
- the energy gained by the gas is not transferred quickly enough to its surroundings.

Key terms

Write a definition for these key terms.

boiling condensation conservation of mass density evaporation freezing fusion
internal energy latent heat melting specific latent heat sublimation vaporisation

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

P6 questions

Answers

1	Which two quantities do you need to measure to find the density of a solid or liquid?	Put paper here	mass and volume
2	What happens to the particles in a substance if its temperature is increased?	Put paper here	they move faster and the energy in their kinetic energy store increases
3	Why are changes of state physical changes?	Put paper here	no new substances are produced and the substance will have the same properties as before if the change is reversed
4	Why is the mass of a substance conserved when it changes state?	Put paper here	the number of particles does not change
5	What is the internal energy of a substance?	Put paper here	the total kinetic energy and potential energy of all the particles in the substance
6	Why does a graph showing the change in temperature as a substance cools have a flat section when the substance is changing state?	Put paper here	the energy transferred during a change in state causes a change in the internal energy of the substance
7	What is the name given to the energy transferred when a substance changes state?	Put paper here	latent heat
8	What is the specific latent heat of a substance?	Put paper here	the energy required to change the state of one kilogram of that substance with no change in temperature
9	What is the specific latent heat of fusion a substance?	Put paper here	the energy required to change one kilogram of the substance from solid to liquid at its melting point, without changing its temperature
10	What is the specific latent heat of vaporisation of a substance?	Put paper here	the energy required to change one kilogram of the substance from liquid to vapour at its boiling point, without changing its temperature
11	On a graph of temperature against time for a substance being heated up or cooled down, what do the flat (horizontal) sections show?	Put paper here	the time when the substance is changing state and the temperature is not changing
12	What property of a gas is related to the average kinetic energy of its particles?	Put paper here	temperature