

3. The Kinetic Theory of Matter

Matter is anything that has mass and volume.

Matter is made up of pure substances (elements and compounds) and mixtures.

Pure substances = substances that have distinct properties and their composition doesn't vary from sample to sample.

A mixture is made up of substances mingled together but not chemically combined.

Homogeneous mixture = a uniform composition throughout the mixture

Heterogeneous mixture = does not have a uniform composition throughout

Kinetic theory of matter

The **kinetic theory of matter** is a model we use to explain the nature and behaviour of matter. It states that....

1. Matter is made up of tiny particles.

2. These particles have energy and are constantly in motion. The amount of kinetic energy in a substance is related to its temperature.

The higher the temperature, the higher the energy.

3. A change in energy can lead to a change in state.

The amount of energy changes depending on the temperature of the substance.

4. There is space between the particles of a substance.

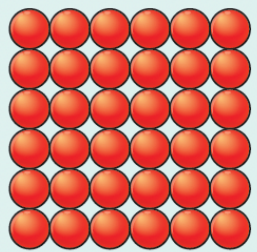
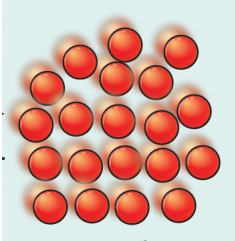
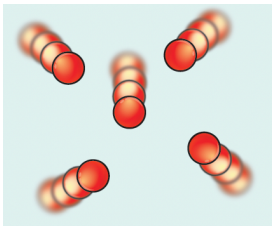
The amount of space varies depending on the state of matter.

5. There are forces between particles.

Particles are attracted to each other by forces, which can be weak or strong.

The kinetic-theory-of-matter model can be used to explain the properties of solids, liquids and gases, and to explain changes in state (e.g. freezing, melting, boiling and condensation).

States of matter

States of matter			
Property	Solid	Liquid	Gas
Diagram			

Attractive forces	Strong	Moderate	Weak
Arrangement of particles	Particles in a solid are tightly packed together, with very little space between particles.	Particles in a liquid are close together, but not as tightly packed as in a solid.	There are large spaces between particles in a gas.
Energy of particles	Low	Moderate	High
Movement of particles	Particles in a solid have the least kinetic energy – the particles are vibrating but cannot move from a fixed position.	Particles in a liquid have more kinetic energy than those in a solid and can flow past each other. Particles are colliding with each other and the walls of the container.	Particles in a gas have the most kinetic energy and are moving rapidly – colliding frequently with each other and the walls of the container.
Shape	Definite shape	No definite shape – liquids take the shape of the container they occupy.	No definite shape – gases diffuse to fill the container they occupy.
Volume	Definite volume	Definite volume	No definite volume
Compressibility	Very difficult to compress	Very low compressibility since there is very little space between the particles.	Due to the large spaces between particles, gases are easy to compress.

Changes of state

- A change of state is a physical change from one state of matter to another – e.g. solid to liquid.
- Changing the temperature changes the energy of the particles.
- **If the temperature is increased, the increased energy is used to overcome the forces of attraction between particles. Therefore, changes in temperature result in changes of state.**
- **During a change of state, temperature is constant.** The added heat energy is used to overcome the forces holding one molecule to another, not to increase the temperature.

Melting is the process by which a solid changes to a liquid.

Freezing is the process by which a liquid changes to a solid.

Vaporisation is the changing of a liquid to a gas.

Boiling is the process by which a liquid changes to a gas when it's heated to its boiling point.

Evaporation is the process by which a liquid changes to a gas below the temperature at which it boils.

Evaporation occurs when some of the higher-energy particles at the surface move fast enough to break free from the liquid and escape into the air as gas, even though the liquid hasn't yet reached its boiling point.

Boiling happens throughout a liquid, while evaporation happens only on the surface.

Condensation is the process by which a gas changes to a liquid.

Sublimation & Desublimation

Sublimation occurs when a solid changes state directly into a gas, without becoming a liquid first.

Desublimation (deposition) occurs when a gas changes state directly into a solid, without becoming a liquid first.

Evidence for the kinetic theory of matter

1. Brownian motion

- A scientist called Robert Brown was using a microscope to study pollen grains in a drop of water.
- He saw that the pollen grains moving around randomly.
- The invisible water molecules were colliding with the pollen grains and causing them to move randomly in different directions.
- This provided evidence for the existence of particles, and evidence that liquid particles are in constant motion.
- This movement of particles is called Brownian motion.

Brownian motion is the random movement of microscopic particles in a fluid due to their collisions with other atoms or molecules.

2. Diffusion of hydrogen chloride (HCl) and ammonia (NH₃) gases

- If a cotton swab soaked in hydrochloric acid is placed at one end of a tube and a cotton swab soaked in ammonia is placed at the other end, after a few minutes a white ring will be observed near the middle of the tube.
- The white ring is ammonium chloride (NH₄Cl) and it forms when particles of hydrogen chloride and particles of ammonia react: $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}$.
- The formation of the ammonium chloride proves that the gas particles are in motion, providing evidence for the kinetic theory of matter.

Diffusion is the movement of particles from an area of high concentration to an area of low concentration.

Limitations of the kinetic theory of matter

- The size, shape and internal structure of the particles is not discussed.
- The theory simplifies the forces between particles – the different types of forces between particles are not discussed.
- Not all particles in a substance have the same amount of energy.