# Chapter 1
# The particulate nature of matter

11C Undarga

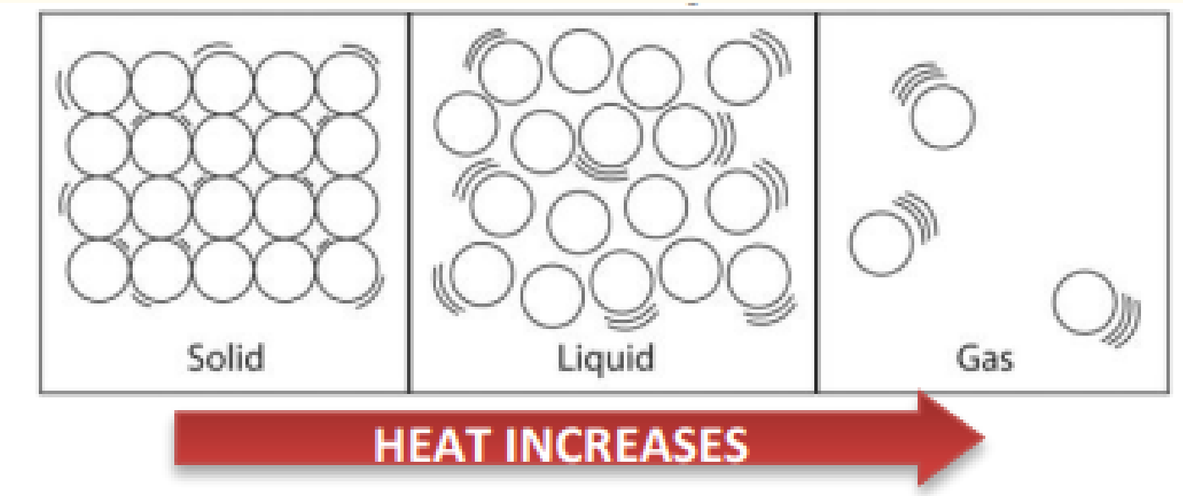
# Kinetic particle theory

The main points of the theory are:

- All matter is made up of tiny, moving particles, invisible to the naked eye. Different substances have different types of particles (atoms, molecules or ions) which have different sizes.

- The particles move all the time. The higher the temperature, the faster they move on average.

- Heavier particles move more slowly than lighter ones at a given temperature.



# Kinetic particle theory

- When a solid is heated, particles vibrate faster about a fixed point causing particles to move further apart and so solid expands.
- When particles gain sufficient energy to overcome strong forces of attraction, they move out of their fixed position and can slide over each other in a continuous random motion – solid has melted.
- Particles in liquid have energy to move around but are still close to each other and do not have enough energy to overcome the forces that hold them close to each other.
- If more heat's supplied, particles move faster until they have enough energy to overcome the forces of attraction. Particles escape the liquids surface and move around in continuous rapid motion – the liquid has boiled.
- In the vapor, the particles move in rapid random motion. This movement is due to collision of vapor particles with air particles.

# States of matter

| Solid | Liquid | Gas |
| --- | --- | --- |
| Strong intermolecular forces | Weaker intermolecular forces than solids | Almost no intermolecular forces |
| Fixed lattice arrangement | No fixed arrangement; particles can move and slide over each other | Particles far apart and move quickly |
| Particles vibrate in fixed position; fixed shape and volume | Particles slide; fixed volume | Random movement; no fixed shape or volume |

# States of matter

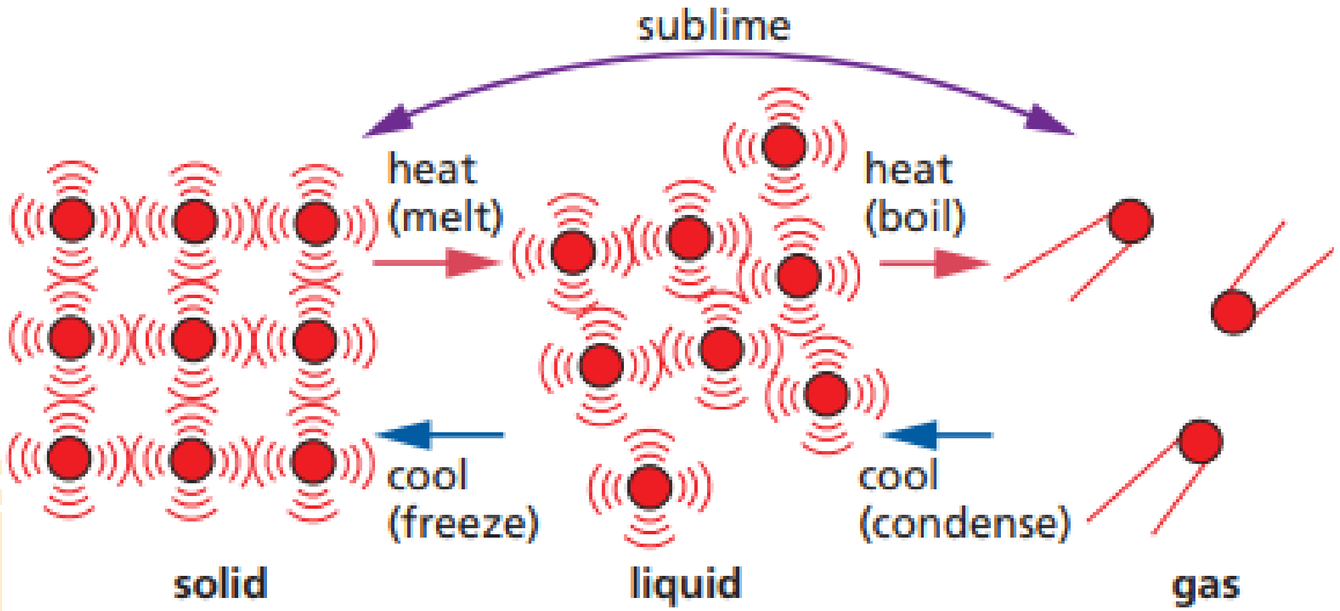
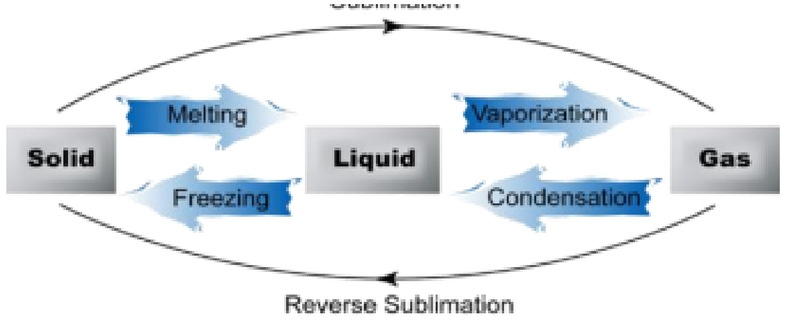
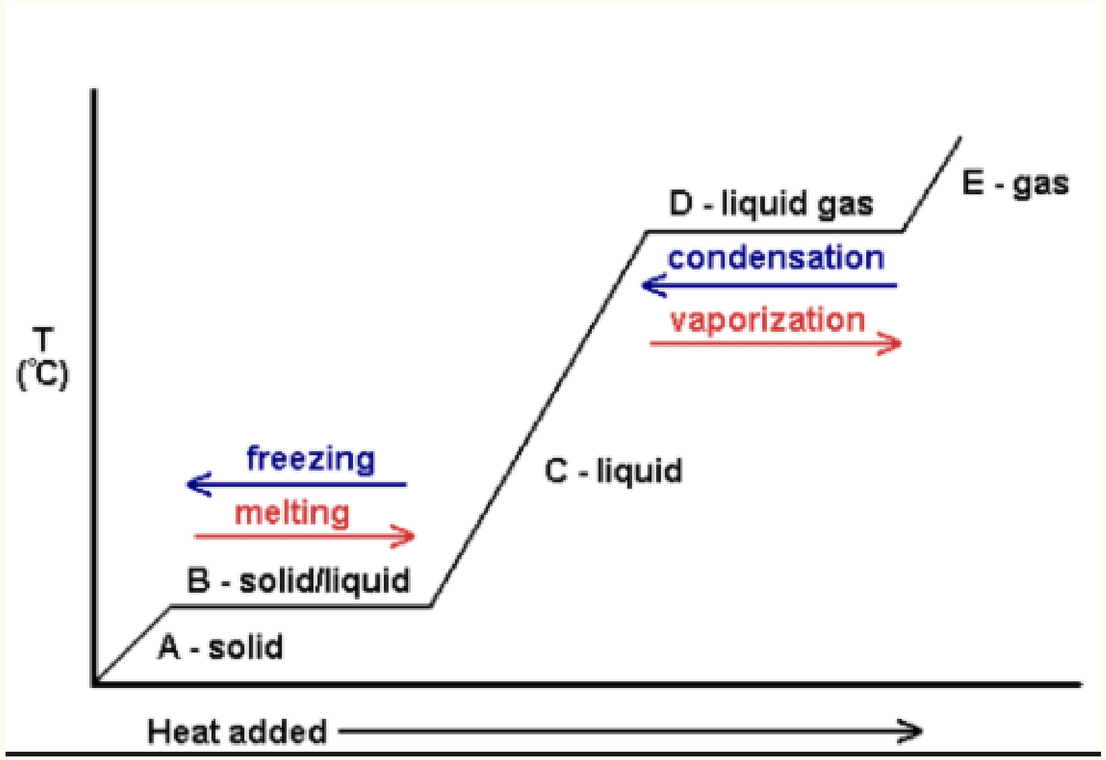



**Figure 1.10** Summary of the changes of state.




| PROCESS | HEAT ENERGY | EXO/ENDOTHERMIC |
|---|---|---|
| Melting | Gained | Endothermic |
| Boiling | Gained | Endothermic |
| Condensing | Lost | Exothermic |
| Freezing | Lost | Exothermic |
| Sublimation | Gained | Endothermic |
| Reverse sublimation | Lost | Exothermic |

# Heating and cooling curves




Heating curves show how the temperature changes as a substance is heated up. Cooling curves are the opposite. They show how the temperature changes as a substance is cooled down.

# Diffusion

## Key definition:

Diffusion is the spreading of one substance (liquid or gas) through another from a region of high concentration to a region of low concentration due to the continuous random motion of particles.

## Evidence for diffusion:

In liquids: potassium manganate (VII) in a beaker of water
In gases: a gas jar of air and a gas jar of bromine connected

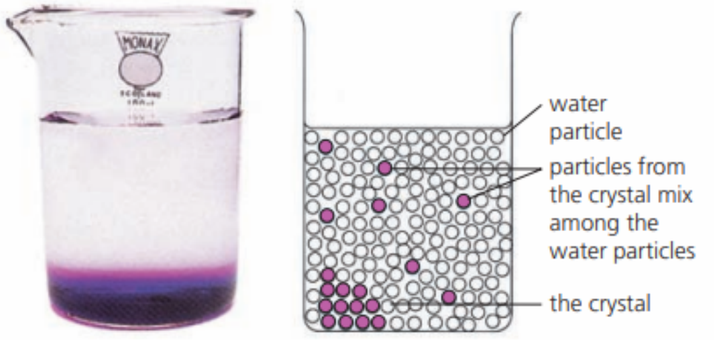
**Figure 1.13** After 24 hours the bromine fumes have diffused throughout both gas jars.

## Factors that affect the rate of diffusion:

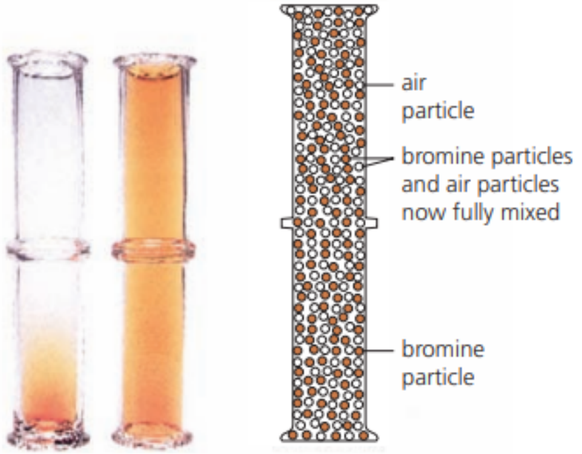
Temperature increases → rate of diffusion increases
Lower relative molecular mass→ rate of diffusion is higher

# Diffusion

## Evidence in the lab




**1** Place a crystal of potassium manganate(VII) in a beaker of water. The colour spreads through the water. Why? First, particles leave the crystal – it **dissolves**. Then they mix among the water particles.




**2** Place an open gas jar of air upside down on an open gas jar containing a few drops of red-brown bromine. The colour spreads upwards because particles of bromine vapour mix among the particles of air.

When diffusion takes place between a liquid and a gas it is known as intimate mixing. The kinetic theory can be used to explain this process. It states that collisions are taking place randomly between particles in a liquid or a gas and that there is sufficient space between the particles of one substance for the particles of the other substance to move into.

# Brownian motion

**Brownian motion:**
It is the random movement of particles in a liquid or a gas caused due to collision with smaller, invisible particles

Evidence:

In liquid- Pollen grains in water

In gases- Smoke in air

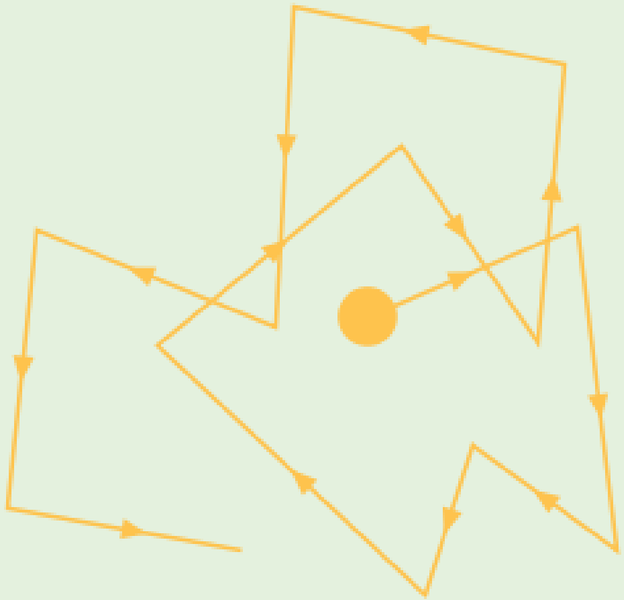
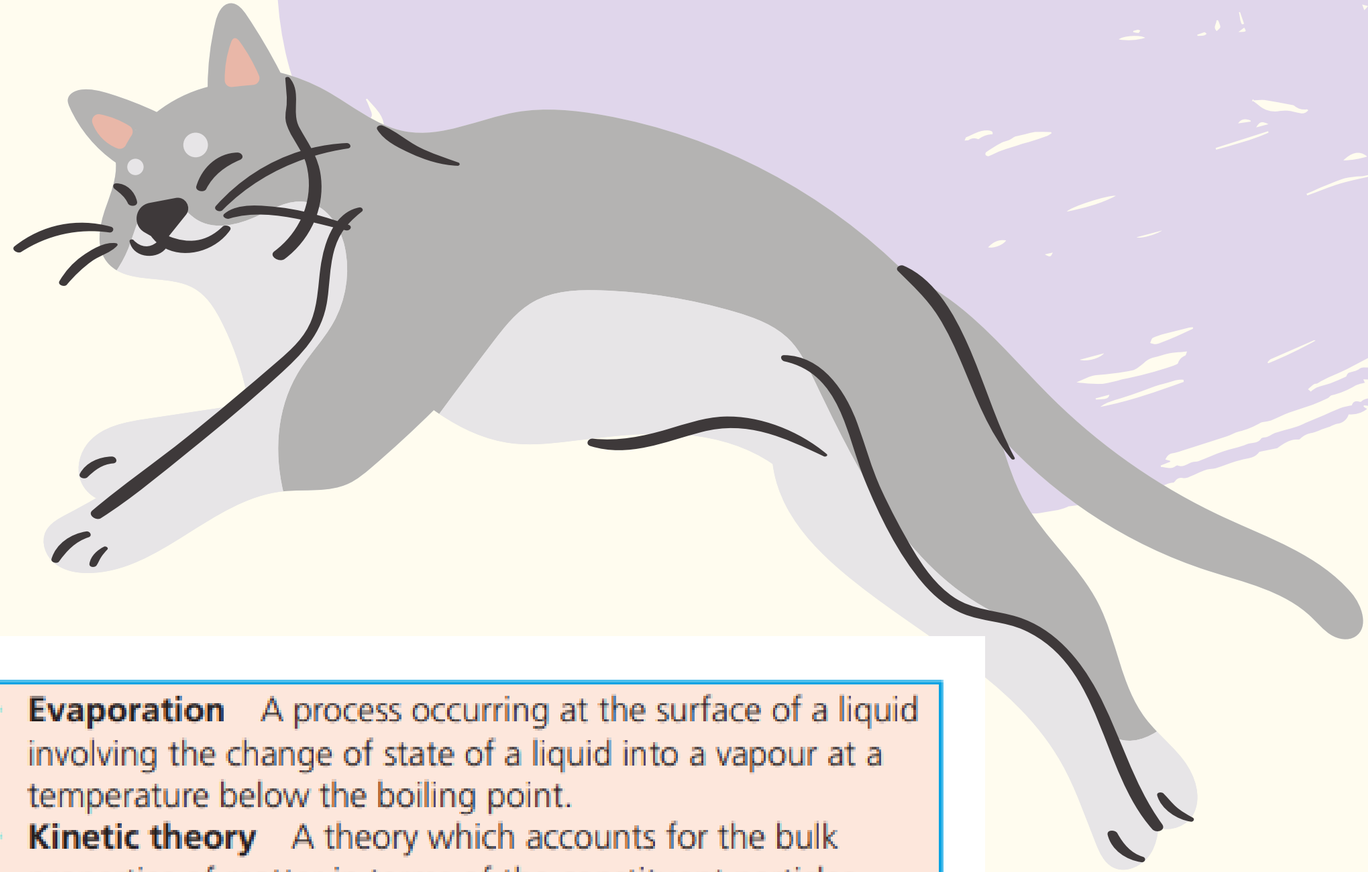


**Figure 1.16b** Brownian motion causes the random motion of the visible particle.

This random motion of visible particles (pollen grains) caused by much smaller, invisible ones (water particles) is called Brownian motion (Figure 1.16b), after the scientist who first observed this phenomenon. It was used as evidence for the kinetic particle model of matter



## Checklist

After studying Chapter 1 you should know and understand the following terms.

- **Atmospheric pressure** The pressure exerted by the atmosphere on the surface of the Earth due to the weight of the air.
- **Boiling point** The temperature at which the pressure of the gas created above a liquid equals atmospheric pressure.
- **Condensation** The change of a vapour or a gas into a liquid. This process is accompanied by the evolution of heat.
- **Diffusion** The process by which different substances mix as a result of the random motions of their particles.
- **Evaporation** A process occurring at the surface of a liquid involving the change of state of a liquid into a vapour at a temperature below the boiling point.
- **Kinetic theory** A theory which accounts for the bulk properties of matter in terms of the constituent particles.
- **Matter** Anything which occupies space and has a mass.
- **Melting point** The temperature at which a solid begins to liquefy. Pure substances have a sharp melting point.
- **Solids, liquids and gases** The three states of matter to which all substances belong.
- **Sublimation** The direct change of state from solid to gas and the reverse process.