IN A STATE

INTRODUCTION

This module introduces the concept of states of matter. Children will learn the characteristic properties of solids, liquids and gases, first through physically exploring typical materials and then by classifying examples, such as powders and very viscous liquids, which are harder to classify. Using first-hand experience and secondary sources they will learn about changes of state and begin to understand freezing and boiling points as identifying characteristics of a material. They will learn the names of some common gases. They will have the opportunity to explore the expansion of liquids and gases when they are heated, using this to make a simple thermometer and explain how it works. They will also learn about the water cycle, modelling it in different ways and further developing their understanding of changes of state. This module focuses on reversible changes; reversibility will be covered in more detail in Year 5, along with other types of change.

National Curriculum:

Compare and group materials together according to whether they are solids, liquids or gases

Observe that some materials change state when they are heated or cooled and measure or research the temperature at which this happens in degrees Celsius °C

Identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature

Working Scientifically:

Identifying differences, similarities or changes related to scientific ideas and processes

Setting up simple practical enquiries, comparative and fair tests

Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions

Identifying differences, similarities or changes related to simple scientific ideas and processes

Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers; reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions

Using straightforward scientific evidence to answer questions or to support their findings

Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts and tables

Scientific Enquiry:

Grouping and classifying

Observing over time leading to fair testing

Fair test

Observing changes over time

Exploring

Exploration and finding things out using secondary sources of information

Observing over time and comparative test

Key vocabulary:

solid, liquid, hard, soft, pour, flow, pile, pool, surface, horizontal, runny, viscous, sticky, grain, powder, ice, water, temperature, cool, cooling, warm, warming, hot, degree Celsius, melt, melting, freeze, freezing, solidify, solidifying, heating, states of matter, change of state, melting point, freezing point, process, gas, air, carbon dioxide, helium, oxygen, bubbles, empty, particle, weight, compress, squash, shape, volume, dry, evaporate, evaporation, water vapour, boil, boiling, boiling point, steam, thermometer, data logger, sensor, droplets, condense, condensation, water, droplets, cycle, model, snow, expand, scale, calibrate, heat sensitive, sensor, observe, measure, fair test, variable, collect, present, interpret, data, axis, scale, interval, control, keep the same, evidence, annotate, accuracy, describe, explain, evaluate, reliable, repeatable

FACT FILE:

Substances occur in three states, **solid**, **liquid** and **gas**. Each has characteristic properties:

- **Solids** retain their shape unless a force is applied to them, for example to cut or shape them. They have **constant volume** (small amounts of expansion when heated are not considered in this module). This is because the **particles** making up the solid are held in a tight structure where they can vibrate but cannot move in relation to each other. Powders can be poured but will form a pile rather than a pool (flat surface). Each grain of a powder maintains its **shape** and **volume**.
- **Liquids** when transferred from place to place take the shape of the container they are in but do not change in volume (although children will learn later in the module that **heating** causes **expansion**). The surface of a liquid will remain horizontal when the container is tipped. The particles in a liquid remain in contact with each other so the liquid cannot be compressed, but they are more loosely bound and so can move in relation to each other, allowing changes of shape.
- **Gases** change in shape and volume to fill the space they are in. The particles in a gas are wide apart and move freely so, under pressure, the gas will take up less space.

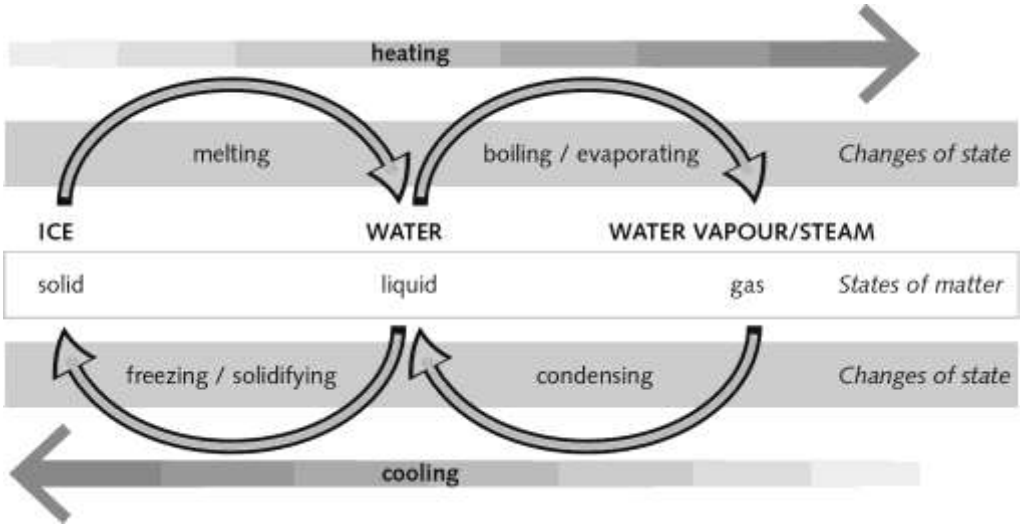
Although the property of **density** is not taught in this module children will be aware that for the same volume a substance is lighter as a gas than a liquid and usually lighter as a liquid than a solid. The exception to this is water, which becomes denser as it cools, but only until it reaches 4°C, when it expands again. This is why, unlike other solids and liquids, solid ice floats on liquid water.

Although solids and liquids do not change in volume, if the temperature and pressure do not change, heating a solid, liquid or gas will cause expansion. Heating gives the particles more energy so they move more and can move further away from each other. Particles in a solid still remain in a structured arrangement and liquid particles still move in contact with each other. Gases expand more than liquids, which expand more than solids. The particles only change in arrangement if they are heated enough to change state.

Changes of state occur as a result of **heating** or **cooling**. They affect the **properties** of the substance but not its **chemical composition**. Water is useful for teaching changes of state because it is familiar to children as ice, water and steam, but they need to understand that the same changes occur when other solids, liquids and gases are heated and cooled. They need to experience this practically and by using secondary sources to find out about materials which change state at very high or low temperatures and which they will only have experienced in one state, such as metal. Changes of state are reversible processes; for example, when ice is heated it melts but the resulting water will become ice again if sufficiently cooled.

- **Melting** is the change from solid to liquid caused by heating.
- **Freezing** or **solidifying** is the change from liquid to solid caused by cooling. The term freezing is usually used when the change happens at low temperatures; solidifying is used for change at higher temperatures but the distinction is not crucial at this stage.
- **Evaporation** is the change from liquid to gas. In the case of water the gas is called water vapour. In everyday language the process may be called drying or drying up. This happens at all temperatures above freezing point with the rate of evaporation increasing as the temperature rises. It happens only at the surface of the liquid, which is why increasing the surface area increases the rate of evaporation.
- **Boiling** is a change from liquid to gas when the liquid is heated to a specific temperature known as its boiling point. It happens throughout the liquid so a boiling liquid contains bubbles of the substance in gas form. Water vapour at 100°C is known as steam.
- **Condensation** is the change from gas to liquid at temperatures between its boiling and freezing points.

Any pure substance has characteristic temperatures at which it freezes (its **freezing point** which, for most materials, is the same temperature as its **melting point**) or boils (**boiling point**). Materials which are mixtures will not have a defined freezing or boiling point. Adding impurities to a substance can change its freezing or boiling point; for example, salty water freezes at a lower temperature than pure water. Pure water has a freezing point of 0°C and a boiling point of 100°C at normal atmospheric pressure. A solid heated to its melting point or a liquid heated to boiling point will show no further change in temperature (the heat energy is all used by the change of state). The levelling off of the time and temperature graph shows where the melting or boiling point is.



The **water cycle** shows how water in the environment evaporates into the air then the warm air cools as it rises leading to condensation and the formation of clouds. Water droplets in the clouds fall as rain (or as snow or hail if cooled below freezing point). The water returns to the sea via streams, lakes and rivers to continue the cycle. Some of it is used by people and animals and some evaporates before it reaches the sea.