Autumn Block 3

States of matter

White Rose SCIENCE

Small steps

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Small steps

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Explore solids, liquids and gases

Notes and guidance

In this small step, children are introduced to materials and objects which can be grouped into solids, liquids and gases. They look at the properties of solids, liquids and gases and relate these to the common uses of the materials. Children also explore the similarities and differences between solids, liquids and gases.

Children learn that solids have a defined shape and a fixed volume. They should understand that a solid material will keep its shape if it is transferred from one container to another.

Children learn that liquids keep the same volume when they are poured into different containers. They should also understand that gases move to fill any space available, so will move in and out of open windows and can move around the room.

Things to look out for

- Children may think that solid materials cannot change shape. Some solid materials can be squashed, bent, twisted or stretched.
- Children may think that the volume of a liquid changes when it is poured into different containers.
- Children may think that all solid materials are heavy.

Key questions

- What is this object?
- What material is it made from?
- What are the properties of solids, liquids and gases?
- Why is water described as a liquid?
- Why is a table described as a solid?
- Is this a solid, a liquid or a gas?

  How do you know?
- What are the similarities and differences between these materials?
- How can we group these materials?

  How many ways can you think of?

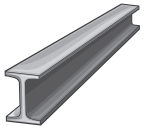
National curriculum links

- Compare and group materials together, according to whether they are solids, liquids or gases.
- **Working scientifically** – Talk about criteria for grouping, sorting and classifying (non-statutory).

Explore solids, liquids and gases

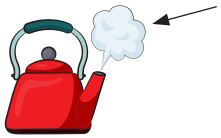
Key vocabulary

- **solid** – a material or object with a defined shape and a fixed volume



- **liquid** – a state of matter with no fixed shape but a fixed volume

- **gas** – a state of matter with no fixed shape and no fixed volume



- **volume** – the amount of space a solid, liquid or a gas takes up

- **states of matter** – these are solids, liquids and gases. Materials can be grouped into these three states of matter

Practical ideas

- Use three balloons: one filled with water and frozen, one filled with water and one blown up with air.

In small groups, ask the children to discuss the similarities and differences between the balloons. What do they notice?

- Transfer solids from one container to another to understand that both the shape and volume do not change.

  Repeat this task with liquids. Children should notice that the shape of liquid changes but the volume does not change.

- Ask children to press the tyre of a bicycle. Explain that it can be pressed in as the gas can be squashed. This is why gases are used to fill bicycle and car tyres.

Factual knowledge

- Solids have a defined shape and volume. A solid material will keep its shape if it is transferred from one container to another.
- Liquids have no fixed shape and will take on the shape of the container they are transferred into. The volume will remain the same.
- Gases have no fixed shape and no fixed volume. They will spread out and fill any available space.

Think differently – solids, liquids and gases

Notes and guidance

In this small step, children explore materials that are more difficult to categorise. They should explore materials such as toothpaste, shaving foam and oobleck (a mixture of corn starch and water) to challenge their thinking around how to categorise materials into each state of matter.

Children should explore examples of materials that challenge their definitions of solids, liquids and gases. This includes solid materials that can be poured and liquids that flow slower than water such as honey, oil and treacle.

Children may use a Venn diagram to sort materials, as they could choose to group certain materials between a solid and a liquid for example.

Key questions

- What is a pouring solid?
- What materials are pouring solids?
- How are oil and honey similar/different to water?
- If you pour sand, how is it different to pouring water?

  Why?
- Is toothpaste a solid, liquid or a gas?

  How do you know?
- Which materials are more difficult to categorise as solids, liquids or gases?
- Why are these materials difficult to categorise as either solids or liquids?

Things to look out for

- Children may think that it is only liquids that can be poured. Some solids, such as sand, sugar and rice, are solid materials that can be poured.
- Children may think that when a liquid is poured and it flows slower than water, it is not a liquid. Oil and syrup are liquids that both flow slower than water.

National curriculum links

- Compare and group materials together, according to whether they are solids, liquids or gases.
- **Working scientifically** – Identifying differences, similarities or changes related to simple scientific ideas.

Think differently – solids, liquids and gases

Key vocabulary

- **pouring solid** – a solid that can be poured like a liquid

- **volume** – the amount of space a solid, liquid or gas takes up

- **oobleck** – a material made from corn starch and water

- **flow** – to move easily in one direction

Practical ideas

- Explore pouring solids such as sand and rice by transferring them from one container to another. Children can observe how these are different to liquids as they will not fill the bottom of the container and will form a pile.

- Observe how when a force is applied to oobleck it behaves like a solid, but when no force is applied it can pour like a liquid.
- Use a Venn diagram to sort materials into solids, liquids and gases. Children may state that some cannot be categorised easily into one group but may explain why they have chosen to place them between a solid and a liquid, for example.

Factual knowledge

- Some solids, such as sand, salt, flour and rice, can be poured but they are still classified as solid materials.
- Liquids maintain the same volume if transferred to different containers.
- Some liquids, like water, flow easily while other liquids, like treacle, do not flow as easily.

Change states

Notes and guidance

In this small step, children build on their understanding of the states of matter and look at how some materials can change states between a solid, liquid and gas.

The terms "evaporation" and "condensation" are introduced for the first time and these concepts will be built upon later in the block when children explore the water cycle.

Children should see that temperature changes can cause changes in state. They should explore the concepts of melting and freezing through simple hands-on activities. This may be through observing an ice cube or piece of chocolate melt and freezing different liquids.

Key questions

- What materials can melt?
- How can the melting process be sped up?
- How can a material change state from a solid to a liquid?
- How can a material change state from a liquid to a gas?
- How can a material change state from a liquid to a solid?
- How can a material change state from a gas to a liquid?
- What is "condensation"?
- What is "evaporation"?

Things to look out for

- Children may confuse boiling and evaporation. They may think that evaporation can only occur when water boils at 100°C.
- Children may think that once a material has melted it cannot turn back to a solid. Demonstrate that this process is reversible by melting and freezing an ice cube or a piece of chocolate.

National curriculum links

- 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).
- **Working scientifically** – Asking relevant questions and using different types of scientific enquiries to answer them.

Change states

Key vocabulary

- **freezing** – the state change when a liquid turns to a solid

- **melting** – the state change when a solid turns to a liquid

- **boiling** – the state change when a liquid turns to a gas as it is heated. Boiling produces visible bubbles

- **condensation** – the state change where gas turns to a liquid

- **evaporation** – the state change when a liquid turns to a gas

Practical ideas

- Children should observe how some materials change state through hands-on, practical experience.
  - Boil a kettle to show how liquid changes state to a gas.
  - Freeze different liquids to show how liquid changes state to a solid.
  - Melt different materials (chocolate, ice, butter) to show how a solid changes state to a liquid.
  - Breathe onto a mirror or cold window to create condensation to show how water vapour changes state to a liquid when cooled down.

Factual knowledge

- Some materials can change states between solids, liquids and gases.
- Water can be a solid (ice), liquid (water) or a gas (water vapour).
- When heat is applied to ice, it melts and turns to water. When water is heated it turns into a gas. Water has a boiling point of 100°C.
- To change water vapour (gas) back to water (liquid) it needs to be cooled down as it returns to its liquid state.
- To change water to ice, it needs to be frozen. Water freezes at 0°C.

Use equipment

Notes and guidance

In this small step, children work scientifically to understand how to use a thermometer and a stopwatch accurately. This is so they can use these pieces of equipment within an experiment in the next two small steps.

In maths in Year 2, children read scales on thermometers. However, this will be the first time they are introduced to using a thermometer to take multiple readings of temperature.

It is important that when children are measuring the temperature of hot water it is not above 50°C, to ensure health and safety regulations are met.

Key questions

- How could you measure the temperature of a cup of water?
- How could you measure the time taken to run a race?
- Why would you use a thermometer to measure temperature, rather than just guess?
- What does "°C" stand for?
- How would you know if the temperature increases/decreases?
- What units can you use to measure time?
- How do you use a stopwatch to accurately measure time?

Things to look out for

- Thermometers may only have been seen as a pictorial representation rather than being used to measure temperature. Therefore, they may not read the scales accurately.
- Children may be confused with how to read the time on a stopwatch in minutes and seconds in digital time.
- If scientific thermometers are used, there may be some confusion if they have negative temperatures.

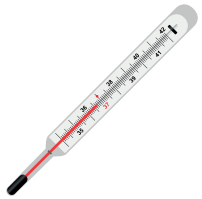
National curriculum links

- 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).
- **Working scientifically** – Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers.

Use equipment

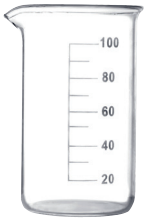
Key vocabulary

- **thermometer** – a piece of equipment used to measure temperature



- **stopwatch** – a watch with start and stop buttons which can be used to take exact measurements of time

- **beaker** – a transparent piece of equipment used to hold and measure liquid



- **temperature** – the measure of how hot or cold something is

Practical ideas

- Children should work in small groups to take accurate readings from a thermometer.

  Give each group a beaker and add hot water.

  Ensure the water is no hotter than 50°C.

  Ask children to take the temperature of the water in two-minute intervals. How does the temperature change over time?

- Children can work in pairs to learn how to use a stopwatch accurately.

  Use these questions as suggestions for tasks:

  - How quickly can your partner write the alphabet?
  - How quickly can your partner name five countries?

  Children can record their times in seconds.

Factual knowledge

- A thermometer is a piece of equipment that is used to measure temperature.
- Stopwatches are used to measure intervals of time.

Plan – melting experiment

Notes and guidance

In this small step, children plan a fair test to investigate whether the temperature of the water affects the time it takes for ice to melt. This will be the first step in which they have planned a fair test within the Year 4 curriculum, so children will need to discuss variables before the experiment.

Children do not need to use the terms "independent", "dependent" and "controlled variables" as these are introduced later in KS2. Instead, they can focus on what they are changing, measuring and keeping the same.

Children may need to complete the experiment plan as a whole group to ensure that all children have made a relevant prediction, discussed the variables involved and can explain how they will record their results.

Key questions

- What does "melt" mean?
- What will you change?
- What will you measure?
- What will you keep the same?
- What equipment will you use and why?
- How will you record your results?

Enquiry question

- How does the temperature of the water affect the time it takes for ice to melt?

Things to look out for

- Care will need to be taken when children read the thermometer and the stopwatch, especially if they convert minutes and seconds into seconds. Using a bar model may help children to convert between minutes and seconds.

National curriculum links

- 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).
- **Working scientifically** – Setting up simple practical enquiries, comparative and fair tests.

Plan – melting experiment

Experiment variables

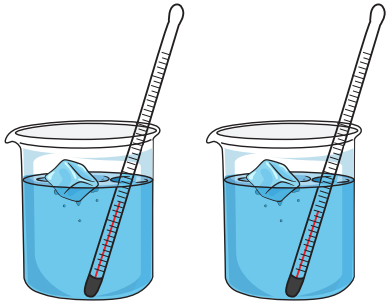
- **independent variable** (what will change) – the temperature of the water

- **dependent variable** (what will be measured) – the time it takes for ice to melt

- **controlled variable** (what is kept the same) – the volume of water in the containers, the size of containers, the size and shape of the ice cube and whether the liquid is stirred or not

Equipment needed

- two beakers of equal size
- thermometer
- stopwatch
- hot water
- cold water
- two ice cubes of similar size



Practical activity

- Put children in small groups.

  Give each group the equipment needed for the experiment.

  Children should identify what the equipment is and why it is used within the experiment.

Planning sentence stems

- I predict that…

  I think this will happen because…

- We are changing the…

  We are measuring the…

  We are keeping _____ the same.

Investigate – melting experiment

Notes and guidance

In this small step, children carry out an experiment to investigate whether the temperature of the water affects the time it takes for ice to melt. This is the first step in which they have carried out a fair test in the Year 4 curriculum, so a discussion of variables before the practical experiment is essential.

Children should set up practical equipment and make systematic and careful observations throughout. With support, children need to identify the relationship between temperatures and melting rates.

It is important that the water cannot be over 50°C when children are measuring temperatures, to comply with health and safety guidelines.

Things to look out for

- Children may struggle to take multiple accurate readings from a thermometer.
- When recording their results, the units for temperature (°C) should be put in the table heading and not next to every reading.
- Children may struggle to form a conclusion from their data.

Key questions

- What are the starting temperatures of the water in container A and container B?
- What do you notice in container A?
- How is that different to container B?
- What are the final temperatures in container A and container B?
- What did you notice? What does that tell you?

Enquiry question

- How does the temperature of the water affect the time it takes for ice to melt?

National curriculum links

- 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).
- **Working scientifically** – Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions.

Investigate – melting experiment

Key vocabulary

- **melting** – the state change when a solid turns to a liquid

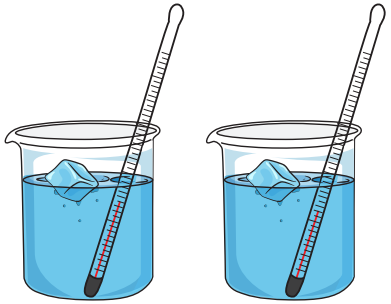
- **thermometer** – a piece of equipment used to measure temperature

- **melting point** – the temperature at which a given solid will melt

- **stopwatch** – a watch with start and stop buttons which can be used to take exact measurements of time

Equipment needed

- two beakers of equal size
- thermometer
- stopwatch
- hot water
- cold water
- two ice cubes of similar size



Method

1. Add hot water to beaker A and cold water to beaker B.
2. Measure the starting temperatures in beaker A and beaker B.
3. Record these temperatures in the results table.
4. Add one ice cube into beaker A and one into beaker B.
5. At the same time, start the timer on the stopwatch.
6. Observe closely as the ice cubes melt.
7. Once the ice cube has melted in beaker A, record the time it took to melt and measure the final temperature.
8. Observe closely to see when the ice cube has melted in beaker B.
9. Record that time in the results table and measure the final temperature in beaker B.

The water cycle

Notes and guidance

In this small step, children look at the water cycle. They build on their understanding of evaporation and condensation from previous steps and look at these processes as parts of the water cycle.

Within this step, children should understand that new water is not made in the water cycle. The water cycle began around four billion years ago and recycles water. They also learn that water does not have to boil to turn into water vapour and that precipitation is not just rain, it also includes hail, sleet and snow.

There are possibilities to look at the impact that climate change is having on the water cycle. As air temperatures increase, more water evaporates into the air. Warmer air can hold more water vapour, which can lead to more intense rainstorms and extreme flooding.

Things to look out for

- Children may think that the Sun absorbs water.
- Children may think that clouds are a gas (water vapour) and not water/ice droplets in the atmosphere. It is the water that makes clouds visible.

Key questions

- What is the process of evaporation?
- What could increase the rate of evaporation?
- What is the process of condensation?
- What is the difference between boiling and evaporation?
- Dinosaurs such as the T-Rex drank water. How can children in the school have drunk the same water?
- Why is it important not to waste water?
- What other ways can you think of to reduce the wasting of water?

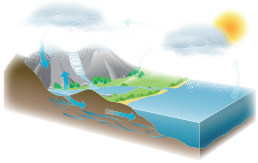
National curriculum links

- 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 simple scientific ideas and processes.

The water cycle

Key vocabulary

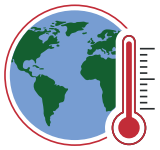
- **the water cycle** – the natural recycling and movement of water on planet Earth



- **precipitation** – liquid or frozen water that falls back to Earth from the atmosphere. This can be in the form of rain, hail, sleet or snow

- **atmosphere** – the layer of gases that surrounds the Earth

- **global warming** – the gradual increase in the temperature of the Earth



- **water vapour** – the gaseous state of water

Practical ideas

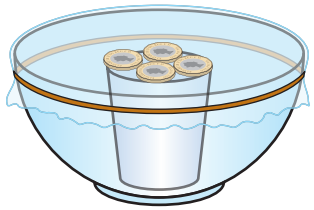
- Create a model water cycle using a cup and a plastic bowl.

  Put a small cup inside a clear plastic or glass bowl.

  Pour warm water into the bowl until it is two-thirds of the way up the cup.

  Do not put the water into the cup.

  Cover the bowl with cling film and secure with an elastic band. Put a weight on top of the cling film (e.g. coins).

  After a few hours, some water will have evaporated and formed condensation on the plastic.

  This will then fall as "rain" into the cup.

Factual knowledge

- A large amount of planet Earth is covered in water.
- Water is in constant movement through a process called the water cycle. As the water moves it can be in different states of matter.
- Evaporation is one stage of the water cycle. Evaporation is where a liquid changes state to a gas.
- Condensation is when a gas changes state to a liquid.

Plan – evaporation experiment

Notes and guidance

In this small step, children plan an experiment to investigate whether temperature affects the time it takes for water to evaporate.

They explore the question, "How does temperature affect the time it takes for water to evaporate?". Children put the same volume of water in shallow dishes (such as Petri dishes) in three different locations. Ensure that the temperature in each area is different to allow children to make conclusions in the next step. For example, in the fridge, in the classroom and on top of a radiator. This will provide children with three varying temperatures.

Within this investigation, measuring time in hours is the most appropriate measure of time as minutes and seconds would be too quick to observe the process of evaporation.

Things to look out for

- Children may need support with the explanations of why the equipment they have chosen is the most appropriate apparatus.
- Children may think that evaporation will not occur in any conditions under 100°C.

Key questions

- What is evaporation?
- What will you change?
- What will you measure?
- What will you keep the same?
- What do you predict will happen?

  Why do you predict that will happen?
- How will you record your results?

National curriculum links

- Identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature.
- **Working scientifically** – Asking relevant questions and using different types of scientific enquiries to answer them.

Plan – evaporation experiment

Experiment variables

- **independent variable** (what will change) – the temperature of the different locations.

- **dependent variable** (what will be measured) – the time it takes for the water to evaporate.

- **controlled variable** (what is kept the same) – the volume of water in the containers, the size of containers, the initial temperature of the water in all the containers.

Equipment needed

- three Petri dishes (or shallow dishes)
- water
- measuring cylinder
- thermometer
- three areas to place the Petri dishes (on top of a radiator, in the classroom away from a heat source and in the fridge)

Practical activity

- Put children in small groups.

  Give each group the equipment needed for the experiment.

  Children should identify what the equipment is and why it is used within the experiment.

Planning sentence stems

- I predict that…

  I think this will happen because …

- We are changing the …

  We are measuring the …

  We are keeping _____ the same.

Investigate – evaporation experiment

Notes and guidance

In this small step, children carry out an experiment to explore whether temperature affects the rate of evaporation. They should set up practical equipment and make systematic and careful observations throughout. Ensure that children are aware of how to measure the volume of liquids and the temperatures of the different areas accurately. With support, children need to identify the relationship between higher temperatures and quicker rates of evaporation.

When recording their data, children may choose to use statements to record how much water has evaporated over time or as numerical data using a scale. For example, 1 – all of the water has evaporated and 5 – the amount of water has remained the same.

Key questions

- Does the temperature affect the rate of evaporation?
- What will you change?
- What will you measure?
- What will you keep the same?
- What is the starting temperature in each area?
- What was your prediction?
- Did you notice any changes?

  What were they?

Things to look out for

- Children may choose to use a large volume of water and fill the Petri dish. Choosing a smaller volume of water will allow children to observe the evaporation process more easily.
- Children may confuse the processes of boiling and evaporation. Explain to children that evaporation can occur at any temperature above 0°C.

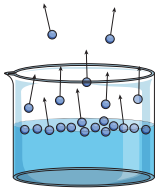
National curriculum links

- Identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature.
- **Working scientifically** – Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers.

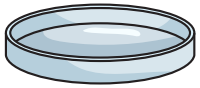
Investigate – evaporation experiment

Key vocabulary

- **evaporation** – the process when a liquid turns to a gas



- **Petri dish** – a shallow, circular and transparent dish

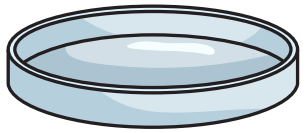


- **observations** – the method of closely watching something before writing any results and a conclusion

- **data** – facts and numerical information collected

Time (hours)	Location		
	Classroom	Radiator	Fridge
1			
2			
3			
4			

Equipment needed



- three Petri dishes or shallow dishes
- water
- measuring cylinder
- thermometer
- three areas to place the Petri dishes (on top of a radiator, in the classroom away from a heat source and in the fridge)

Method

1. Measure the volume of water and add the same amount of water to each of the Petri dishes.
2. Place the dishes in the chosen areas.
3. Measure the starting temperature in each area.
4. Record these temperatures with the correct unit (°C).
5. Check every hour and note down observations throughout.
6. Take the temperature every hour to see if there are any temperature changes throughout the experiment.
7. Observe each area to see which has the quickest rate of evaporation.
8. Record the observations using either factual statements or an agreed numerical scale.

Evaluate – evaporation experiment

Notes and guidance

In this small step, children work scientifically to analyse data, make conclusions and evaluate their experiment. Children can use the evaluation sentence stems to structure their written analysis and evaluation. This is the first time children have evaluated an experiment in Year 4 and therefore they may need support to make conclusions using their data and create an evaluation.

Children could compare their data to other groups to allow them to spot patterns and identify anomalous results. In Year 4, children do not need to use the term "anomalous". However, they should be encouraged to spot any differences in data and discuss why these may have occurred.

By the end of this step, children should identify that higher temperatures increase the rate of evaporation as they change state to a gas more quickly.

Things to look out for

- Children may think that temperature does not affect the rate of evaporation.
- Children may think that the water has "disappeared" from the container rather than evaporated.

Key questions

- What effect does temperature have on the rate of evaporation?
- What conclusions can you make from your data?
- Are there any similarities or differences between your results and the results of other groups?

  Why do you think this has happened?
- If you were to repeat this experiment again, how could you improve your results?
- What questions do you have for further investigation?

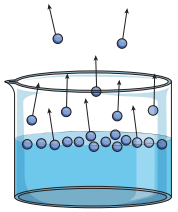
National curriculum links

- Identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature.
- **Working scientifically** – Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions.

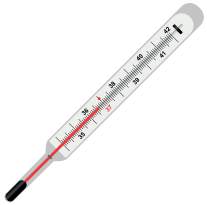
Evaluate – evaporation experiment

Key vocabulary

- **evaporation** – the process when a liquid becomes a gas



- **temperature** – the measure of how hot or cold something is



- **conclusion** – what has been found during an investigation based on experimental measurements and observations

Location: Fridge		
Time in hours	Temperature (°C)	Has the water evaporated?
1	4	No
2	4	No
3	4	No

Practical ideas

- Children may want to investigate whether different materials have a different rate of evaporation.

- Children could create a presentation to explain their findings from the experiment.

  A discussion could be held to identify the problems with the investigation and how they can be avoided if the experiment is done again.

Evaluation sentence stems

- I predicted that …
- My prediction was correct/incorrect because …
- From looking at our results, I can see that …
- This happened because …
- To make our investigation more accurate, we could …
- For future investigation, I would like to find out …