Autumn Block 3

States of matter

White Rose SCIENCE

Small steps

Step 1	Explore solids, liquids and gases
Step 2	Think differently – solids, liquids and gases
Step 3	Change states
Step 4	Use equipment
Step 5	Plan – melting experiment
Step 6	Investigate – melting experiment
Step 7	The water cycle
Step 8	Plan – evaporation experiment

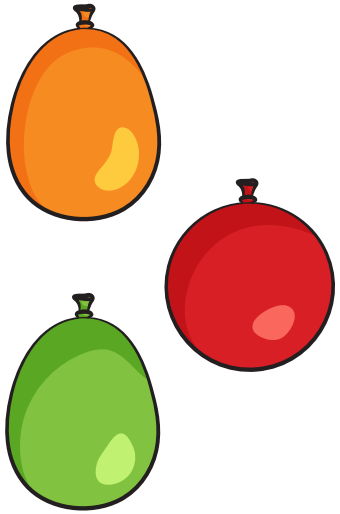
Small steps

Step 9	Investigate – evaporation experiment
Step 10	Evaluate – evaporation experiment

Key resources

Step 1 – Explore solids, liquids and gases

- three balloons – one filled with water and frozen, one filled with water and one filled with air
- water
- a wide range of containers with different shapes, sizes and capacities
- solid materials



Step 2 – Think differently – solids, liquids and gases

- liquids – oil, treacle, honey, water
- toothpaste
- shaving foam
- jam
- oobleck – a mixture of cornstarch and water
- fizzy drinks in a plastic bottle
- pouring solids – sand, salt, rice, flour
- containers
- solid materials

Step 3 – Change states

- ice
- paper towels
- kettle
- water
- materials to melt, e.g. chocolate, butter

Step 4 – Use equipment

- two beakers per small group
- kettle
- hot water (⚠ no hotter than 50°C)
- cold water
- one stopwatch per group
- one thermometer per small group

Key resources

Step 5 – Plan – melting experiment

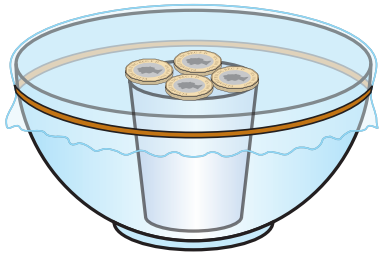
- ice cubes
- thermometer
- beakers (two per group)
- hot water
  (⚠ no hotter than 50°C)
- cold tap water
- stopwatch

Step 6 – Investigate – melting experiment

- ice cubes
- thermometer
- beakers
- hot water
  (⚠ no hotter than 50 °C)
- cold tap water
- stopwatch

Step 7 – The water cycle

- diagram of the water cycle
- cup and plastic bowl, cling film, elastic band, weight e.g. coins for the model water cycle



Step 8 – Plan – evaporation experiment

- Petri dishes or shallow dishes
- thermometers
- measuring cylinders
- water

Key resources

Step 8 – Plan – evaporation experiment

- Petri dishes or shallow dishes
- thermometers
- measuring cylinders
- water

Step 10 – Evaluate – evaporation experiment

- Petri dishes or shallow dishes
- thermometers
- measuring cylinders
- water
- different materials for further investigation into rates of evaporation

Explore solids, liquids and gases

Notes and guidance

In this small step, children learn that materials and objects 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 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 a liquid keeps the same volume when it is poured into a different container. They also learn that a gas moves to fill any space available, so it 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 could you group these materials?

  How many ways can you think of?

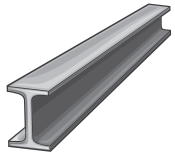
National curriculum links

- 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

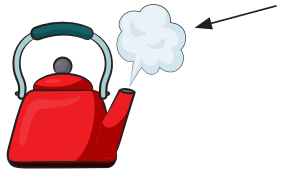
Key vocabulary

- **solid** – a state of matter with a fixed 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** – the different forms that materials can take

Practical ideas

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

  Ask children to discuss in small groups the similarities and differences between the balloons. What do they notice?

- Transfer solids from one container to another to show children that the shape and volume do not change. Repeat this with liquids. Children should notice that the shape of the liquid changes but the volume does not change.
- Ask children to press the tyre of a bicycle. Explain that it can be pressed in because the gas can be squashed. This is why gases are used to fill bicycle and car tyres.

Factual knowledge

- Solids have a fixed 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, such as toothpaste, shaving foam and oobleck (a mixture of corn starch and water). This will 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 sorting 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?
- What 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 flows slower than water, it is not a liquid. Oil and syrup are liquids that 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 smoothly and continuously in one direction

- **states of matter** – the different forms that materials can take

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 because they will form a pile rather than filling the bottom of the container like a liquid.
- Show children that 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 sorting 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 when transferred to different containers.
- Some liquids, like water, flow easily while other liquids, such as 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 through 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 occur only 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 change of state from a liquid to a solid

- **melting** – the change of state from a solid to a liquid

- **boiling** – the change of state from a liquid to a gas, which happens quickly when heated and creates bubbles of the gas

- **condensation** – the change of state from a gas to a liquid

- **evaporation** – the change of state from a liquid to a solid, which happens slowly from the surface of the liquid

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 they change state to a solid.
  - Melt different materials 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 state between a solid, a liquid and a gas.
- Water can be a solid (ice), a liquid (water) or a gas (water vapour).
- When heat is applied to ice, the ice melts and turns to water. When water is heated it turns into a gas.
- 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.

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 guidelines are met.

Key questions

- How would you measure the temperature of a cup of water?
- How would you measure the time it takes 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 has increased/decreased?
- What units can you use to measure time?
- How do you use a stopwatch to measure time accurately?

Things to look out for

- Children may not read the scale on a thermometer accurately. Demonstrate to them how to do this.
- 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.

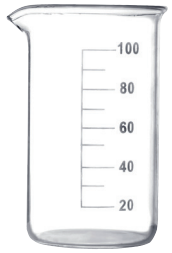
Use equipment

Key vocabulary

- **thermometer** – equipment that measures temperature

- **stopwatch** – equipment that measures time, with start and stop buttons

- **beaker** – equipment that holds a liquid



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

Practical ideas

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

  Give each group a beaker of hot water.

  Ensure the water is no hotter than 50°C.

  Ask children to take the temperature of the water in five-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 activities.

  - How quickly can your partner write the alphabet?
  - How quickly can your partner name five food items?
  - How quickly can your partner write their name backwards?

  Children can record their times in seconds.

Factual knowledge

- A thermometer is used to measure temperature.
- A stopwatch is 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 in it. 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" because these are introduced later in KS2. Instead, they can focus on what they are changing, measuring and keeping the same.

Children may need to plan the experiment as a whole group to ensure that they all make a relevant prediction, discuss 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

- Children may not convert minutes and seconds into seconds accurately. They may find it helpful to use a bar model.

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 the 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 equal 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 a fair test to investigate whether the temperature of the water affects the time it takes for ice to melt in it. 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 the experiment. 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, children should put the units for temperature (°C) in the table heading and not next to every reading.
- Children may struggle to form a conclusion from their data.

Key questions

- What is the starting temperature of the water in container A and container B?
- What do you notice in container A?
- How is that different to container B?
- What is the final temperature of the water in container A and container B?

Enquiry question

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

National curriculum links

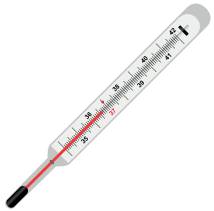
- Observe that some materials change state when they are heated or cooled, and measure or research the temperature at which this happens in degrees Celsius (°C).
- **Working scientifically** – Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions.

Investigate – melting experiment

Key vocabulary

- **melting** – the change of state from a solid to a liquid

- **thermometer** – equipment that measures temperature



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

- **stopwatch** – equipment that measures time, with start and stop buttons

Equipment needed

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

Method

1. Add hot water to beaker A and cold water to beaker B.
2. Measure the starting temperature in beaker A and beaker B.
3. Record these temperatures in a results table.
4. Add one ice cube into beaker A and one into beaker B at the same time.
5. Start the timer on the stopwatch.
6. Observe closely as the ice cubes melt.
7. Record the time it takes for the first ice cube to melt.
8. Measure the final temperature of the water in the first beaker.
9. Record the time it takes for the second ice cube to melt.
10. Measure the final temperature in the second beaker.

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 learn that the water cycle began around four billion years ago. They should understand that water is recycled in the water cycle and no new water is made. In addition to this, they learn that water does not have to boil to turn into water vapour and that precipitation 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 drink the same water?
- Why is it important not to waste water?
- What other ways can you think of to reduce the wasting of water?

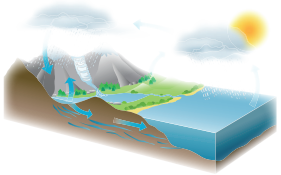
National curriculum links

- 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 processes which recycle and move water around Earth



- **precipitation** – solid or liquid water that falls from the atmosphere, in the form of rain, hail, sleet or snow

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

- **condensation** – the change of state from a gas to a liquid

- **evaporation** – the change of state from a liquid to a gas, which happens slowly from the surface of the liquid

Practical ideas

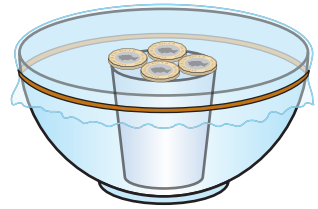
- Create a model water cycle using a cup and a plastic bowl.

  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

- Nearly three-quarters of planet Earth is covered in water.
- Water is in constant movement through a process called the water cycle. As the water moves it is in different states of matter.
- Evaporation is one stage of the water cycle. Evaporation is when 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 the temperature of the air affects the time it takes for water to evaporate. They put the same volume of water in shallow dishes (such as Petri dishes) in three locations with different temperatures for example, in the fridge, in the classroom and on top of a radiator. This will allow children to make conclusions in the next step.

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

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?

Things to look out for

- Children may struggle to explain why the equipment they have been given is the most appropriate for the experiment.
- Children may think that evaporation will not occur in any conditions below 100°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** – 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 variables** (what is kept the same) – the volume of water in the containers, the size of the containers, the initial temperature of the water in all the containers

Equipment needed

- three Petri dishes (or shallow dishes)
- water
- measuring cylinder
- thermometer
- three locations to place the Petri dishes

Practical activity

- Put children in small groups.

  Give each group the equipment they need 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 set up practical equipment and make systematic and careful observations throughout the experiment. Ensure that children know how to measure the volume of liquids and the temperatures of the different locations 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 use numerical data with 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 location?
- 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.

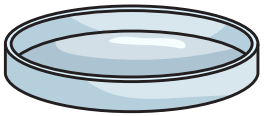
National curriculum links

- 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

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



- **observe** – to use your senses to examine something

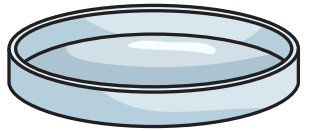
- **data** – information collected, such as facts, observations or numbers

Time passed (hours)	Location		
	Classroom	Radiator	Fridge
1	no change	no change	no change
2	no change	some of the water has evaporated	no change

- **evaporation** – the change of state from a liquid to a gas, which happens slowly from the surface of the liquid

Equipment needed

- three Petri dishes or shallow dishes
- water
- measuring cylinder
- thermometer
- three locations to place the Petri dishes



Method

1. Measure the same volume of water into each of the Petri dishes.
2. Place the dishes in the chosen locations.
3. Measure the starting temperature in each location.
4. Check every hour and note down observations throughout.
5. Take the temperature every hour to see if there are any temperature changes throughout the experiment.
6. Observe each location to see which has the quickest rate of evaporation.
7. Record the amount of evaporation 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 should 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. They may therefore they may need support to make conclusions using their data and to create an evaluation.

Children could compare their data with 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 be able to identify that higher temperatures increase the rate of evaporation.

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?

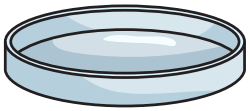
National curriculum links

- 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

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



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

- **conclusion** – what has been found out from an investigation

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

- **evaporation** – the change of state from a liquid to a gas, which happens slowly from the surface of the liquid

Practical ideas

- Children may want to investigate whether evaporation occurs at a different rate with different materials.

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

  They could discuss the possible problems with the investigation and think how these 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 …