# Background knowledge

## Changes of states of matter

When a substance changes from one state or phase of matter to another we say that it has undergone a change of state or a change of phase.

These changes of state always occur with a change of heat. Heat, a form of energy, either comes into the material or out of the material during a change of state. However, although the heat content of the material changes during a change of state, the temperature does not. The table summarises the changes that take place in changes of state.

<table>
<thead>
<tr>
<th>Description of change of state</th>
<th>Term for change of state</th>
<th>Heat movement during change of state</th>
<th>Temperature change during change of state</th>
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</thead>
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<tr>
<td>solid to liquid</td>
<td>melting</td>
<td>heat goes into the solid as it melts</td>
<td>none</td>
</tr>
<tr>
<td>liquid to solid</td>
<td>freezing</td>
<td>heat leaves the liquid as it freezes</td>
<td>none</td>
</tr>
<tr>
<td>liquid to gas</td>
<td>vaporisation, which includes boiling and evaporation</td>
<td>heat goes into the liquid as it vaporises</td>
<td>none</td>
</tr>
<tr>
<td>gas to liquid</td>
<td>condensation</td>
<td>heat leaves the gas as it condenses</td>
<td>none</td>
</tr>
</tbody>
</table>


## Solutions

A solution is a mixture in only one state of matter in which the different components of the mixture cannot be seen. Solutions consist of two substances: a solute and solvent. The solute is the substance dissolved in the solvent. The solvent does the dissolving. The solution takes on the state of matter of the solvent. For example if solid salt is dissolved in water, the solution will be in the liquid state. When the particles of the solute dissolve, they cannot be with naked eyes.

Usually, the substance present in the greatest amount is considered the solvent. Solvents can be solids, liquids or gases. In most cases the solvent is a liquid. Solutes can also be solids, liquids or gases. Learners will be most familiar with solid solutes, such as sugar and salt. Carbon dioxide gas is the solute in fizzy drinks. Liquid solutes can be cool-drink concentrates, which are mixed with water (the solvent), or drops of vanilla or other flavouring added to a liquid cake mix.
# Unit overview

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<td>Exercise 3.5</td>
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<tr>
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<td>1</td>
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#### 3.7 Boiling
- **Activity 3.7a**
- **Activity 3.7b**
- **Questions 1–4**
- **Challenge question**

#### 3.8 Melting
- **Activity 3.8**
- **Questions 1–3**

#### 3.9 Who invented the temperature scale?
- **Questions 1–5**

### Check your progress
- **Questions 1, 2, 3, 4, 5**

### Resources
- a bucket
- chalk
- water
- construction paper
- a permanent marker
- a measuring jug, cup or cylinder
- glasses, beakers and jars
- a range of liquids such as fruit juice, cooking oil, syrup and washing up liquid
- small equal-sized squares of different fabrics, about 5 cm x 5 cm
- paper cups (of the same size and shape)
- paper clips
- string
- hand sanitiser
- paper
- containers with different-size openings, such as jars, bowls, baking pans and water bottles
- copper sulfate or potassium permanganate crystals
- a teaspoon
- salt
- sand
- filter paper
- filter funnel
- shallow container
- glasses
- ice
- cloth
- plastic wrap
- marking pen
- food colouring
- a plastic bag
- a small bucket or similar container
- elastic bands
- a hotplate or Bunsen burner
- a thermometer
- a stopwatch, digital watch or watch with second hand
- a measuring spoon

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**Topic 3.1 Evaporation**

The key concepts explored in this topic are that liquids become gases by the process of evaporation, and that temperature affects the rate of evaporation.

**Learning objectives**

- Know that evaporation occurs when a liquid turns into a gas.
- Use knowledge and understanding to plan how to carry out a fair test.
- Measure volume, temperature, time, length and force.
- Identify factors that need to be taken into account in different contexts.
- Use observation and measurement to test predictions and make links.

**Curriculum links**

- You can link this lesson with stage 4, where learners explored the different phases of matter. This topic builds on their knowledge of how materials change when they are heated and cooled.

**Ideas for the lesson**

- Begin by discussing some of the learners’ own experiences of water evaporating. Ask the class questions such as: If you hang wet clothes up, will they eventually get dry? Where do you think the water goes? If you forget your towel when you go swimming, you can dry off by just standing around. How does that happen? What are some other examples of water drying up?
- Learners might mention examples such as puddles drying up, or dishes drying on a drying rack. Ask them what happened to the water in all these examples. Then get learners to do Activity 3.1a.
- If it has rained recently, get learners to use a piece of chalk to trace a line around the perimeter of a puddle. If you are in a dry region or it is not the rainy season, you can make your own puddle. Pour a bucket of water onto the ground, preferably in a slight dip or hollow on tar or concrete where it won’t drain into the soil or run off immediately. Learners should return to the puddle two or three more times during the day to trace the new outline. Encourage them to think about the factors that affect how the puddle dries up.
- Make it clear in all the examples that although you can’t see the water any more, it still exists. It changes into the gas, water vapour, which is an invisible gas in the air. Explain that when water changes from a liquid to a gas, we say that it evaporates.
- Ask questions about the conditions in which washing dries best. Get learners to suggest factors that will affect evaporation. They will know from their own experience that wind is a factor. Then get learners to do Activity 3.1b which requires them to measure volume and compare loss of water by evaporation under different conditions. They will need to leave the experiment for two days before making their observations and answering Questions 1 to 4 about the activity. Check that learners are able to measure the volume of water correctly. Demonstrate the correct technique to use and give assistance where needed.
- Worksheet 3.1 requires learners to plan and conduct a fair test to find out about which liquids evaporate the fastest. Remind them about the features of a fair test. What factors will they measure? Which factor will they keep the same? Which factors will they change? Learners should also start thinking about whether or not they have enough evidence to form a conclusion. They should consider whether or not they will get the same results if they repeat the test. Explain that scientists don’t do an experiment just once. They do it many times to check that their results are true and that they have not made any errors in carrying out the experiment or measuring the results. Only then do they form a conclusion.
- Learners will need to do the investigations in Activity 3.1b and Worksheet 3.1 over two to three days. Carry on with teaching the next topic during this time.

**Notes on practical activities**

**Activity 3.1a**

Each group will need:

- a glass
- some water
- a sheet of construction paper.

Learners should work in groups of 4 or 5.
Give each group a half-filled glass or cup of water and give each learner a piece of construction paper. Keep a piece of construction paper for yourself. Demonstrate how to dip an index finger into the water, tap off the excess water, and rub a small circle of water in the middle of the paper on one side. Challenge learners to get rid of the water spot on their construction paper without touching the water spot. Point out that, while they are doing that, you are going to place your paper to the side and leave it alone.

Learners might wave the paper in the air or put it somewhere warm.

Once all the water spots evaporate, get learners to deduce what happened to the water by asking questions such as these:

What happened to the water on the paper?

Possible answers might include: the water does not exist anymore; the water became invisible, the water soaked into the paper, or the water dried up.

What did they do to help get rid of the water spot?

What happened to the water on your piece of paper that had nothing done to it?

(The water also disappeared or evaporated.)

If the water is not on the paper, where did the water go?

(It went into the air.)

If any learners say the water is still in the construction paper, have them tear the paper into pieces and feel it for dampness. They should discover that the paper is dry and no longer holds any absorbed water. If some learners still think the water remains absorbed by the material it rests on, consider giving them more experiences with evaporation by doing the alternative evaporation activity.

Activity 3.1b

Each group will need:
- two identical glasses
- some water
- a permanent marker
- a measuring jug.

Learners should work in groups of 4 or 5.

Demonstrate to the class how to measure volume. (See the Reference section of the Learner’s Book.) Set up your own experiment as a comparison. Learners can compare their group’s result with those of other groups. To enable this to happen, you should collate the results of all the groups on the board. Use this as an opportunity to discuss the need for repeated observations and measurements. You can also talk about the importance of collecting enough evidence to test an idea; in this case that water will evaporate faster in warm conditions.

Worksheet 3.1

Each group will need:
- a different liquid such as water, fruit juice, cooking oil, syrup, washing up liquid
- beakers or jars
- a measuring jug or cylinder
- a marking pen.

Learners should work in groups of 4 or 5.

Learners should do the activity over two to three days. They should use volumes of liquid of about 50 ml, otherwise evaporation will take longer than two or three days.

Learners should fill each beaker or jar with a different liquid, and mark the level on each cup. They should place the cups in the same area so that all conditions, other than the type of liquid, are the same. Learners should check the levels of the liquids periodically. Rather than decant the liquids into a measuring cylinders to measure volume evaporated, which can be messy and time-consuming, learners can measure the distance between the original marked level of the liquid and the level after two days.

Remove and dispose of the liquids if you see any sign of mould growth. Learners should draw a bar chart of their results.

Alternative activity or demonstration

Each group will need:
- water
- a glass or paper cup
- small equal-sized squares of different fabrics, about 5 cm × 5 cm
- paper clips
- string.

If time is an issue, use a lightweight fabric such as cotton, or a quick-drying material such as polyester, to obtain the results more quickly. Hang the fabric on a line made of
string so that the fabric is not touching any other surface. By doing the activity this way, any misunderstanding that the water soaks into some other material is dispelled.

Give each learner a piece of fabric. Have them soak it in the cup of water and squeeze out all the excess water. Have them use a paper clip to spear a hold through the fabric and hang it to dry on a line in the classroom.

Once all the water has evaporated, ask the learners these questions:

*What happened to the water?*
(It evaporated.)

*Where did the water go?*
(If any learners say that the water remains in the fabric, have them cut the fabric in half and feel for dampness.)

**Internet and ICT**

**Assessment**
- Do learners know what evaporation is and how it happens? Discuss answers to Exercise 3.1 in the Activity Book in class, and allow learners to check their own work for self-assessment.

**Differentiation**
- Lower achieving learners who are struggling with measuring volume can be assisted if you demonstrate the correct way to do this.
- Higher achieving learners can complete Worksheet 3.1. The worksheet should be done over two to three days.

**Common misunderstandings and misconceptions**
- The most common misconception about evaporation is that the water disappears and does not exist any more, or that it changes into air or dries up and goes into the air. This is due the fact that learners cannot see where the water has gone. You will need to explain that the water evaporates, changing from a liquid to a gas.

**Talk about it!**
The liquid in the paint has a smell. When the liquid evaporates it becomes a gas. Our noses can smell the gas in the air. When the paint is dry, the smell disappears because all the liquid has evaporated.

**Homework ideas**
- Exercise 3.1 in the Activity Book.

**Answers to Learner’s Book questions**
1. no
2. The glass in the cool place. It was cool, so not much water evaporated as the water particles did not absorb much heat.
3. The glass in the warm place. The water particles were heated and had more energy than the water particles in the cool place so more evaporation took place.
4. The heat energy of the Sun makes the water evaporate quickly. Wind also helps washing dry.

**Answers to Activity Book exercise**

**Exercise 3.1**
1. Evaporation occurs when a liquid turns into a gas. The particles in the liquid gain energy and move faster and further apart until some of them escape from the surface and become a gas.
2. It evaporates so that the cement dries out.
3. The heat makes the water in the puddles evaporate faster than on cooler days because that the particles in the puddle gain heat energy which makes them move faster and further apart and change into water vapour more quickly.

**Answers to Worksheets**

**Worksheet 3.1**
1. Different liquids such as water, fruit juice, cooking oil, syrup, washing up liquid; beakers or jars; measuring jug or cylinder; marking pen.
Unit 3 Teaching ideas

2 The volume of each liquid, the place the liquids are put, use identical beakers or jars to put the liquids in, the length of time each liquid is left.

3 The type of liquid.

4 Use identical beakers or jars to put the liquids in.

Measure the same volume of liquid to go in each beaker or jar.

Put all the jars in the same place for the same length of time.

5 a Water will evaporate the most.

b A bar chart.

c Do the investigation a few times.

Yes/no, depending on prediction.

6 Results will depend on type and volume of liquid used, environmental conditions and time over which investigation was conducted. This is a possible graph.

[Graph showing volume of water evaporated in ml vs. different liquids]

7 No. Other liquids would also have to be tested and these liquids should be tested several times.

Topic 3.2 Why evaporation is useful

The main idea explored in this topic is that evaporation is a useful process.

Learning objectives

- Know that evaporation occurs when a liquid turns into a gas.

- Make relevant observations.

- Identify factors that need to be taken into account in different contexts.

Curriculum links

You can link this lesson with stage 4, where learners explored the different phases of matter. This topic builds on their knowledge of how materials change when they are heated and cooled.

Ideas for the lesson

- Begin by discussing the pictures on page 36 in the Learner’s Book. Ask if learners can think of any other examples of when evaporation is useful. Answers could include paint and cement drying, or cooking foods such as rice, lentils and maize meal. (You could also refer to the website mentioned in the Internet and ICT section.)

- Hand sanitisers are another way that we use evaporation in real life. You can demonstrate their use in class. Pour some hand sanitiser on your hands and rub your hands together, as if you were washing your hands. After waiting a few seconds, your hands are dry. The hand sanitiser has evaporated off your hands. This demonstration can lead into the role of evaporation in cooling. When your hands are wetted by the hand sanitiser, they feel cooler. Explain that evaporation is a cooling process.

- Discuss why we sweat, and how the evaporation of sweat cools the body surface. As the temperature rises, your body begins to produce sweat. As the sweat evaporates, it carries with it some of the heat from your body, causing your body to cool down. Then get learners do Activity 3.2 in which they identify air movement or wind as a factor which affects evaporation.

- Exercise 3.2 in the Activity Book will challenge higher achieving learners.

Notes on practical activities

Activity 3.2

Your breath feels warm.

Blowing on your hand feels cooler than your breath.

Licking and blowing on your hand feels cooler than just blowing. The reason for this is that any water on your hand uses heat energy from your body to evaporate. Blowing makes the water evaporate faster so that your hand feels cooler.
Internet and ICT

- The website: www.tes.co.uk/teaching-resource/Photos-of-examples-of-evaporation-in-everyday-life-KS2-6013358/ has examples of the use of evaporation in everyday life. You will need to subscribe to this website, which is free and very easy to use.

Assessment

- Can learners explain how heat and wind affect evaporation? Ask learners how a tumble drier makes our washing dry and how blowing on wet nail varnish makes it dry faster.

Differentiation

- Higher achieving learners can complete Exercise 3.2 in the Activity Book. As a further extension, they could make a dried food product and bring it to class.

Talk about it!

It is better to stay fully dressed because this will slow down evaporation from the body. This means that the person won’t dehydrate as quickly. It will also prevent sunburn.

Homework ideas

- Questions 1–3 in the Learner’s Book make a suitable homework task. Discuss answers in class and allow learners to check their own work for self-assessment purposes.

Answers to Learner’s Book questions

1. It heats up the water in your hair which means that the water evaporates more quickly. It blows away the water vapour and speeds up evaporation in the same way that wind does.

2. a. Suggestions can include dried fruit, dried beans, dried milk, dried fish
   
   b. Learners should be able to explain the drying process involved in making a food product they have named.

3. The heat from the Sun and the wind make water in the soil evaporate more quickly.

Answers to Activity Book exercise

Exercise 3.2

1. dried peaches

2. a. Peaches, metal tray or wire rack.
   
   b. Put the peaches on the tray or rack and leave it in the Sun, or in an oven at a low temperature.

3. Evaporation is not useful to us when it makes water in dams dry up/makes the soil in our gardens very dry. Lakes or ponds drying out due to evaporation cause the creatures living there to lose their habitat; and reservoirs getting low during a drought mean that people may lack drinking water. A forgotten pot boiling dry can cause a fire.

Topic 3.3 Investigating evaporation

In this topic, learners investigate factors that affect evaporation.

Learning objectives

- Know that evaporation occurs when a liquid turns into a gas.
- Present results in bar charts and line graphs.
- Recognise and make predictions from patterns in data and suggest explanations using scientific knowledge and understanding.
- Measure volume, temperature, time, length and force.
- Identify factors that need to be taken into account in different contexts.

Curriculum links

- This topic links with Mathematics, as learners explore the effect of surface area on evaporation, do subtraction calculations and draw a bar chart.

Ideas for the lesson

- Draw on learners’ prior knowledge and experience of evaporation to get the class to identify factors that affect evaporation. They should be able to name temperature and wind.
Unit 3 Teaching ideas

- Learners can then do Activity 3.3a which requires them to measure the volume of water in the containers over period of five days. This fulfils the scientific enquiry objective of measuring volume. Ask them what trend they see in the results. They should observe that more water evaporated from the container in the warm place than the container in the cool place.

- Ask learners to repeat Activity 3.1a from topic 3.1, but this time ask them to use two pieces of paper. They should fold one piece of paper twice and leave the other piece unfolded as before. Observe the two pieces of paper after five minutes. Why one is drier? Ask the class why they think the folded piece of paper is not as dry as the unfolded piece. Get them to think about the size of the exposed surface. Which is larger?

- Then get learners do Activity 3.3b and answer Questions 1 to 4. After three days, learners should observe that there is less water in the container with the widest opening and they should be able to identify size of the exposed surface (or surface area) as a factor that affects evaporation.

- Exercise 3.3 in the Activity Book is a useful support exercise.

- Use Worksheet 3.3 to extend more able learners. Learners are asked to draw a graph, look for patterns and interpret results.

Notes on practical activities

Activity 3.3a

Each group will need:
- two containers of the same size and shape such as jars
- water
- a measuring jug.

Learners should work in groups of 4 or 5.

Make sure that learners know how to measure volume accurately. Discuss how learners think they will measure the volume in each container before they start. Learners should measure volume by pouring the water from the container into the measuring cylinder and reading the measurement. They should then pour the water back into the container. This should be done with both containers of water.

If you do not have measuring jugs and cylinders available, learners can mark the level of water in each jar at the start with a marking pen. They can measure the distance between the original marked level of the liquid and the new water level each day. The results will be accurate enough for them to see the pattern that water evaporates faster in warm conditions.

Evaluate whether 200 ml was too much or too little water to evaporate in five days, given your local climate, classroom temperature and humidity and other variables. The volume of water that evaporates will depend on the environmental conditions as well as the diameter of the container. This is a set of possible results.

<table>
<thead>
<tr>
<th>Days</th>
<th>Volume of water in ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Container in warm place</td>
</tr>
<tr>
<td>1</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>160</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
</tr>
<tr>
<td>4</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
</tr>
</tbody>
</table>

Activity 3.3b

Each group will need:
- a measuring cup
- containers with different-size openings, such as jars, bowls, baking pans and water bottles.

Learners should work groups of 4 or 5.

In this activity, learners will need to measure physically the volume of water in each container because the containers are different and so the water levels cannot easily be compared using the marking pen method described above.

Ask learners to predict from which container most water will evaporate and why. Give learners a chance to volunteer their evaporation observations. Ask questions that help learners reflect on what they observed, such as:

What did they observe about the volume of water in their containers?

(The amount of water decreased.)

Did they find anything surprising about how much water evaporated from each container?

How accurate were their predictions about which container the most water would evaporate from?
The volume of water that evaporates will depend on the prevailing environmental conditions as well as the diameter of the container. This is a set of possible results.

<table>
<thead>
<tr>
<th>Container</th>
<th>Volume of water in ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>jar</td>
<td>70</td>
</tr>
<tr>
<td>bowl</td>
<td>60</td>
</tr>
<tr>
<td>baking pan</td>
<td>40</td>
</tr>
<tr>
<td>bottle</td>
<td>80</td>
</tr>
</tbody>
</table>

Internet and ICT

- The website: http://people.southwestern.edu/~kamenm/auburn/su9whisnant.html has ideas for investigating the effect of surface area on evaporation.
- The website: www.preservearticles.com/201012231561/factors-affecting-evaporation.html discusses additional factors that affect evaporation.

Assessment

- Can learners identify factors that affect evaporation? Ask them to name three factors that affect evaporation.
- Can learners explain how surface area affects evaporation? You can use this example to find out. Ben left his wet bath towel in a heap on the floor. Alice hung her wet bath towel up on the towel rail. Ask learners which towel will be dry in the morning and why.

Differentiation

- Lower achieving learners may not be sure which type of chart to use to represent their results. Explain when to use bar charts and when to use line graphs. Refer to the Reference section in the Learner’s Book. We use bar charts when we are dealing with results for different objects or groups, which have a value measured for each one, for example, volume of water evaporated from different shaped containers over a specified period of time. Line graphs are used when there is smooth change or progression in the factor being measured over time, such as volume of water evaporated or an increase in temperature or plant height.
- Higher achieving learners can extend Activity 3.3a by investigating the problem posed in Question 4 on how wind or moving air affects evaporation. They should make the investigation a fair test and record their results in a line graph.

Talk about it!

There is less water in the reservoir behind shallow dams than in the reservoir behind deep dams, so the water particles heat up faster, causing more water to evaporate than from deep reservoirs.

Homework ideas

- Exercise 3.3 in the Activity Book for lower achieving learners.
- Worksheet 3.3 can be done by higher achieving learners. Discuss the answers in class and allow learners to check their own work for self-assessment purposes.

Answers to Learner’s Book questions

Activity 3.3a

1. Water evaporates more quickly from the container in the warm place than from the container in the cool place.
   OR
   More water evaporates from the container in the warm place than from the container in the cool place.
2. A line graph. Line graphs are used when there is smooth change or progression in the factor being measured over time, such as volume of water evaporated or an increase in temperature or plant height.
3. a. Evaporation happens more quickly when it is warm.
   b. Repeat the investigation several times.
4. Instead of putting one container in a warm place and the other in a cool place, you could let a fan blow onto one container but not onto the other container.

Activity 3.3b

1. a. Yes, the amount of water has gone down.
   b. In the baking pan.
   c. It evaporated.
2. a. The size and shape of the containers was different.
   b. Different amounts of water evaporated from the different containers.
Unit 3 Teaching ideas

3 Yes, everything else in the test except the containers was the same. The containers were placed in the same place and exposed to the same environmental conditions for the same length of time.

4 a The container affects evaporation.
   OR
   More water evaporates from large open containers with a large surface.
   b Repeat the investigation with other containers with different sizes and shapes.

Answers to Activity Book exercise

Exercise 3.3

1 a

<table>
<thead>
<tr>
<th>Container</th>
<th>Volume of water at start in ml</th>
<th>Volume of water after two days in ml</th>
<th>Volume of water evaporated in ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

b A bar chart. We use bar charts when the results for different objects or groups have a value measured for each one, for example, volume of water evaporated from different shaped containers over a specified period of time.

2 a Container D
   b It has the largest/widest open surface.

3 a Container C
   b It has the smallest/narrowest open surface.

4 No, it was not a fair test. A different volume of water was used in the saucer (container B).

Answers to Worksheets

Worksheet 3.3

1

2 a two hours
   b four hours
   c five hours

3 a Between 07:00 and 08:00 in the first hour.
   b Between 11:00 and 12:00 in the last hour.

4 a Evaporation speeds up as more time passes.
   b At 07:00, it is still quite cool outside. As the temperature increases more evaporation occurs. It is hot between 11:00 and 12:00 so most evaporation takes place then.

5 Faster – wind speeds up evaporation.

Topic 3.4 Investigate evaporation from a solution

The key concept explored in this topic is that solutions consist of a solute and a solvent that can be separated by evaporation.

Learning objectives

- Know that evaporation occurs when a liquid turns into a gas.
- Know that when a liquid evaporates from a solution the solid is left behind.
- Make predictions of what will happen based on scientific knowledge and understanding, and suggest and communicate how to test these.
• Use observation and measurement to test predictions and make links.

Curriculum links
• There is a strong link between this topic and the particle model of matter that was covered in Stage 4. The particle model helps to explain how solutions form. In Stage 2, learners also investigated substances that can dissolve in liquids.

Ideas for the lesson
• Ask learners what happens when they stir sugar into tea. Where does the sugar go? Does it disappear, or is it still in the tea, but not visible? Explain that, when they stir the sugar into the tea, they are making a solution.
• Discuss the components of solutions and then let learners do Activity 3.4a. Talk about what happened in the solution they made. Explain that particles of the solvent moved out of the way to make room for the particles of the solute to fit between them. Eventually the solute particles were evenly spread between the solvent particles. This is why the solution looks uniform (the same all the way through). Stirring makes the particles spread out more easily. The following drawing illustrates how the particles spread out in a solution. You can redraw it on the board to aid your explanation.
• In Activity 3.4b, learners apply their knowledge about evaporation to a new situation. They will need to make a prediction, based on their existing knowledge, about what happens to the salt solution and test the prediction.
• Worksheet 3.4 requires learners to use two methods of separation to remove the salt from the sand. They will make a prediction and then observe whether their prediction was correct. You can ask learners if the mixture they make of salt, sand and water is a solution. Why or why not? You can tell learners that solutions cannot be separated by filtering. Is the filtered liquid that flows into the container a solution? Why or why not?

Notes on practical activities
Activity 3.4a
Each group will need:
• water
• copper sulfate or potassium permanganate crystals
• a glass jar
• a teaspoon.

Learners should work in groups of 4 or 5.

Remind learners not to taste the copper sulfate crystals because they are poisonous. Although Condy’s crystals are not poisonous, they stain skin, paper, and clothing very easily on contact.

If you do not have copper sulphate, or choose not to use it because it is poisonous, you can use potassium permanganate (Condy’s crystals) instead. It is best to use a coloured crystal because the colour helps learners to see how the solute spreads out in the solution until the solution has a uniform appearance.

Tell learners to stir the solution with the spoon. Get them to observe carefully how the crystals dissolve and spread through the water until the solution has uniform appearance. The copper sulfate spreads out as it sinks to the bottom. The water changes colour to blue.

At first you can see the copper sulfate, but then the crystals disappear but the blue colour remains in the water. The copper sulfate is the solute. The water is the solvent. Other common solutions are dissolving sugar in tea or coffee, dissolving instant coffee granules in hot water and dissolving powdered cool drink in water.

Activity 3.4b
Each group will need:
• salt
• water
• a small container
Unit 3  Teaching ideas

- a measuring jug
- a teaspoon.

Learners should work in groups of 4 or 5.

In this practical activity, learners apply their knowledge of solutions and evaporation to recover salt from a solution. Learners should use shallow containers to speed up the rate of evaporation. You could discuss the container they will use prior to the lesson and ask them to bring a container of their choice from home. It might be interesting to compare results obtained using different containers.

Learners will need to leave the salt solution at least overnight, or possibly longer, depending on where in the world you are. You can ask them where they think a good place would be for the containers. Remind them about the effects of temperature on evaporation.

Prediction: the water will evaporate. The salt will be left behind in the container. A warm place is best so the water will evaporate faster. As moving air or wind speeds up evaporation, leaving the solution outside in the Sun, or next to an open window would be a good idea.

Leave it for a few days.

Worksheet 3.4

Each group will need:
- sand
- salt
- water
- filter paper
- filter funnel
- jar or beaker
- shallow container such as a baking tray
- measuring cylinder.

Learners should work in groups of 4 or 5.

This activity is based on the use of two methods of separation in order to remove salt from sand. If learners have not previously separated mixtures by filtering, you will need to demonstrate the technique to them.

Internet and ICT


Assessment

You can use Worksheet 3.4 to assess learners’ understanding of solutions and evaporation, as well whether they can make a prediction based on scientific knowledge and understanding.

Differentiation

- Lower achieving learners can complete Exercise 3.4 in the Activity Book to help them to consolidate their understanding of the topic and its associated vocabulary.
- Higher achieving learners can be challenged by the ‘Talk about it!’ feature. They will need to do some research to find out the answer. You can also ask them to find out about solutions in which the solute is a gas, such as carbon dioxide in fizzy drinks.

Common misunderstandings and misconceptions

- At this level, it is quite common for learners to think that a substance disappears when it dissolves, especially if the solute is colourless, such as salt or sugar. Using a coloured solute such as potassium permanganate or copper sulfate will help learners to understand that solute changes form and becomes mixed...
completely with the solvent. You can use the particle model of matter to explain that the solute particles fit into the spaces between the solvent particles so that the solution all seems the same.

**Talk about it!**

Yes, it is a solution. Not all solutions are made from a solid and liquid. The solute can also be a liquid. The orange squash concentrate is the solute and the solute is the solvent.

**Homework ideas**

- Questions 1–4 in the Learner's Book. Discuss the answers in class and allow learners to check their own work for self-assessment purposes.

**Answers to Learner's Book questions**

1. Yes/no, depending on prediction made.
2. Any two suggestions such as: use less water in the solution, put container in a warmer place, put container in a windy place/allow fan to blow onto container.
3. I found out that it was possible to separate a solid from a liquid by evaporation.

**Answers to Activity Book exercise**

**Exercise 3.4**

**Aim**

We wanted to find out if you can get salt back from a solution by evaporation.

**Method**

We dissolved some salt in water to make a salt solution and left in a warm place for a few days.

**Results**

After a few days there was salt in the bottom of the container. There was no water. It had evaporated.

**Conclusion**

We found that we can get salt back from a solution by evaporating the water.

**Answers to Worksheets**

The prediction is that learners would expect to see salt crystals.

Learners should make their own observation but they would expect to see salt crystals if all the water had evaporated.

- To dissolve the salt in the water and mix the salt and sand.
- To separate the sand from the salt solution.
- a sand
  b salt solution/salty water
- So that the water could evaporate from the salt solution.
- a Yes (if they predicted the presence of salt crystals). They can explain that when the water evaporated from the solution, the salt was left behind.
  b By filtering and evaporation.
- solute – salt
  solvent – water
- Any two: use less water, use a container with a larger surface such as a bowl or baking pan, use a fan to blow on the solution, put the container in a warmer place or in direct sunlight.

**Article 3.5 Condensation**

The key concepts explored in this topic are that gases such as water vapour condense and become liquids when cooled sufficiently, and that condensation is the reverse of evaporation.

**Learning objectives**

- Know that condensation occurs when a gas turns into a liquid and that it is the reverse of evaporation.
- Know that air contains water vapour and when this meets a cold surface it may condense.
- Make relevant observations.
- Use knowledge and understanding to plan how to carry out a fair test.

**Ideas for the lesson**

- Get learners to breathe on a window pane as suggested in the Learner's Book. Talk about what they observe. Ask them where else they have seen water form on surfaces.
- Then get learners to do Activity 3.5a in which learners observe that drops of moisture form on the glass containing the ice. Make sure that both glasses are dry at the start of the activity. This activity involves
Unit 3 Teaching ideas

Learners thinking about the concept of a fair test.

- Discuss their observations and talk about where the water came from. Make sure they understand that water vapour is an invisible gas in the air, and this is the gas that changes into a liquid. Tell them that this process is called condensation.

- Use simple equations on the board to show that condensation and evaporation are reverse processes.

\[
\text{liquid} + \text{heat} \rightarrow \text{gas} \\
\text{gas} - \text{heat} \rightarrow \text{liquid}
\]

- Learners can then observe the two processes in Activity 3.5b and answer questions 1–4 in the Learner’s Book. Learners should observe that water condensed on the inside of the plastic wrap. Ask them to think about why this happened. What happened to the water in the open glass?

- Exercise 3.5 in the Activity Book encourages learners to apply the knowledge gained during this topic.

Notes on practical activities

Activity 3.5a

Each group will need:

- two glasses
- ice
- water
- measuring jug
- cloth.

Learners should work in groups of 4 or 5.

Make sure both glasses are dry at the start of the activity. Ask learners why only one glass contained ice cubes. This will help them to understand the role of the control in investigations. They should be able to deduce that it helps us show that it is the coldness of the glass containing ice that makes water drops form, as this is the only difference between the two glasses.

Learners’ drawings should be similar to this.

Activity 3.5b

Each group will need:

- two glasses
- plastic wrap
- water
- measuring jug
- marker pen.

Learners should work in groups of 4 or 5.

If you notice that very little evaporation has taken place overnight, leave the investigation for longer. You want learners to realise that the water on the plastic wrap came from the water in the glass. Water evaporated into the air from the open glass. In the closed glass the evaporated water could not enter the air. It stayed in the glass and some of it condensed and changed back into liquid water on the plastic wrap. You can use water coloured with drop of food colouring to reinforce the idea that water droplets form during condensation. Learners should observe that the droplets on the plastic wrap are colourless, not coloured, indicating that it is water that is forming the droplets.

Internet and ICT

- The website: http://lessonplanspage.com/sciencechangestatematter35-htm/ has lesson plans on changes of phase, including condensation.

- The website: http://www.bbc.co.uk/schools/gcsebitesize/science/aqa/heatingandcooling/heatingrev5.shtml gives a useful overview of the effects of heating and cooling.

- The website: http://www.bbc.co.uk/schools/scienceclips/ages/9_10/changing_state.shtml has an interactive game on change of state.

Assessment

- Are learners able to use the correct vocabulary to explain evaporation and condensation? Get them to check one another’s answers to question 4 in the Learner’s Book.
Common misunderstandings and misconceptions

- Learners may think that air turns into a liquid during condensation. Remind them that air contains water vapour which is a colourless gas. It is the water vapour which cools and becomes a liquid. Other gases become liquids at every much lower temperatures.

- Another erroneous idea about condensation is that ‘coldness’ passes through the glass of a window pane or beaker and causes water to form on the other side.

Talk about it!

People can use evaporation to separate the water from the impurities/dirt. They can use condensation to collect the pure/clean water.

Homework ideas

- Exercise 3.5 in the Activity Book. Discuss answers in class and allow learners to check each other’s work for peer assessment purposes.

Answers to Learner’s Book questions

Activity 3.5a

1. No. I wiped the outside of the glasses with a cloth.
2. a. Yes. The glass that contained the ice was wet on the outside.
   b. The water came from water vapour in the air that condensed on the outside of the cold glass.
3. In condensation, a gas changes into a liquid. In evaporation, the opposite happens and a liquid changes into a gas.

Activity 3.5b

1. No, the amount of water in the glasses is not the same.
2. There are drops of water on the inside of the plastic wrap.
3. The same volume of water was in both glasses and the glasses were put in the same place for the same length of time. They only thing that was different was that one glass was covered with plastic wrap.
4. The water in the open glass gained heat and evaporated to form water vapour. In the closed glass the water vapour cooled and condensed to form water droplets on the plastic wrap.

Answers to Activity Book exercise

Exercise 3.5

1. water
2. From the sugar solution.
3. condensation
4. Particles of water vapour in the jar cooled down when they touched the inside of the lid and changed to liquid water.
5. a. Evaporation
   b. No. Evaporation made water vapour form inside jar. The drops of liquid form when water vapour cools and condenses.
6. The liquid in the lid will not taste sweet. When evaporation takes place, only the water particles leave the solution to become water vapour. The sugar stays behind. The water vapour condenses to form the liquid inside the lid.

Topic 3.6 The water cycle

The key concepts explored in this topic are that gases, such as water vapour, condense and become liquids when cooled sufficiently, and that condensation is the reverse of evaporation. These concepts are well illustrated in the water cycle.

Learning objectives

- Know that condensation occurs when a gas turns into a liquid and that it is the reverse of evaporation.
- Know that air contains water vapour and when this meets a cold surface it may condense.
- Identify factors that need to be taken into account in different contexts.

Ideas for the lesson

- Ask the class if they know that the water they drink might be the same water that Albert Einstein (or another famous scientist) drank, or perhaps even the dinosaurs. How is this possible? Tell them the amount of water on Earth never changes. It keeps getting used over and over again.
Unit 3 Teaching ideas

- Write the word ‘cycle’ on the board. Discuss these questions. What do learners think of when they read the word ‘cycle’? What shape best represents a cycle? Have learners ever heard of the water cycle? What do they know about it?

- Then ask learners if they have ever seen rain. Where does rain come from? How does it get into the cloud? Ask them to think back to Activity 3.5b. Where did the water on the plastic wrap come from?

- If possible, show the class a video clip about the water cycle to help them make links with their existing knowledge of evaporation and condensation. You will find a large number of video clips on the internet by using ‘water cycle video clips’ as your search terms.

- You could also make a working model of the water cycle to demonstrate to the class. (See Internet and ICT section.)

- Discuss how evaporation and condensation operate to keep the water cycle going. Then get learners to answer questions 1–7 in the Learner’s Book, which get learners to engage with the diagram of the water cycle in the Learner’s Book.

- In Worksheet 3.6, learners need to apply their knowledge of the water cycle in an imaginary situation. They are asked to design a system that uses evaporation and condensation to remove salt from sea water to produce fresh drinking water. They can also think about the best place to put their system in order to obtain the maximum volume of clean water.

Notes on practical activities

Worksheet 3.6
Each group will need:
- salt
- water
- plastic bag
- jam jar
- small bucket (or similar container)
- elastic band.

Learners should work in groups of 4 or 5.

Allow learners two to three days to carry out the investigation and fill in the worksheet. Suggest that learners think about the principles of the water cycle to design their system. Get them to think about how they will obtain the fresh water, and then how they will collect it. As a hint you could suggest forming a slope down which the water can run into the collecting jar. They can do this by placing a stone or other small weight on the plastic wrap.

Internet and ICT

- The website: http://www.youtube.com/watch?v=ZzY5-NZSzVw is a video clip on the water cycle with a fun approach.


- The website: http://www.creativeeducation.co.uk/videos/watch-video.aspx?id=3390 is a video clip on using evaporation and condensation to purify sea water in an imaginative context.

- The website: http://www-k12.atmos.washington.edu/k12/pilot/water_cycle/teacherpage.html gives background and teaching ideas on the water cycle.

- The website: http://teacher.scholastic.com/dirt/weather.htm has an activity in which learners make their own clouds.

- The website: http://www.kidzone.ws/WATER/ has simple explanation for learners about the water cycle and ideas for activities.

- The website: http://www.ehow.com/how_7832256_make-3d-model-water-cycle.html gives instructions on how to make a working model of the water cycle for the class to observe.

Assessment

- How much do learners know about the processes that happen in the water cycle? Ask them these questions: When and why does it rain? What happens to the rain water once it reaches the ground? What happens to the water when the Sun comes out? What happens to the water vapour in the air when it gets cold?

Differentiation

- Lower achieving learners can answer question 7 in the Learner’s Book and complete Exercise 3.6 in the Activity
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Book to help them consolidate their understanding of the topic and its associated vocabulary.

• Higher achieving learners can complete Worksheet 3.6. Allow them two to three days to carry out the investigation and fill in the worksheet. Ask learners to show their design drawings to the class and explain how their system works.

Common misunderstandings and misconceptions

• Learners may think that new water forms during the water cycle. Explain that it is the same water, in different phases, that goes round and round from the Earth’s surface into the air and back again.

Talk about it!

No. The same water keeps moving between the air and the Earth’s surface.

Homework ideas

Exercise 3.6 in the Activity Book.

Answers to Learner’s Book questions

1  a From the Sun.
    b From plants.
2  Into the air as water vapour.
3  a It forms drops of water.
    b in clouds
4  It falls as rain or snow.
5  a When snow forms in clouds.
    b When snow melts to form water.
6  It keeps moving water between the air and the Earth’s surface so that the Earth doesn’t dry up. It allows us to use the same water over and over again.
7  a Water on the Earth’s surface evaporates and moves up into the air as water vapour.
    b The water vapour cools and condenses as it rises into the air.
    c Rain, snow and hail bring water back to the Earth’s surface.

Answers to Activity Book exercise

Exercise 3.6

1  Box 1
   Water on the Earth’s surface is heated and evaporates into the air as water vapour.

   Box 2
   The air cools as it rises. Some of the water vapour in the air condenses. Drops of water in the air form clouds.

   Box 3
   Drops of water fall from clouds as rain. Liquid water returns to the Earth this way.

2  hail
   snow

Answers to Worksheets

Worksheet 3.6

1  a Put the jam jar into the bucket. Then fill the bucket with sea water. Cover the bucket with plastic and hold it in place with the elastic band. Don’t pull the bag tight across the top of the bucket - it must sag a bit in the middle. Put the bucket in the sun.

   b water drops
   plastic bag
   bucket
   elastic band
   salty sea water
   jam jar
   fresh water

2  Water will evaporate out of the sea water, condense on the plastic bag and run down into the jar. Salt and some water will be left in the bucket, and the jar will contain pure, condensed water.

Topic 3.7 Boiling

The main idea explored in this topic is that water boils at a temperature of 100°C.

Learning objectives

• Know that the boiling point of water is 100°C and the melting point of ice is 0°C.
• Measure temperature.
• Recognise and make predictions from patterns in data and suggest explanations using scientific knowledge and understanding.
• Discuss the need for repeated observations and measurements.
Ideas for the lesson

- Ask learners to describe what happens when water boils. Why do they think these things happen?
- Demonstrate Activity 3.7a and discuss learners' observations. Learners will know that water must be heated in order to boil. Ask learners what the white cloud they observe above the boiling water is. They will probably say steam. Explain that steam is the invisible heated water vapour formed when water boils. What we call steam is really the droplets of water vapour condensing in the air as the hot steam cools.
- Ask how hot water must be to boil. Guide them in their predictions by telling them that cold tap water is about 20–25°C and hot tap water is about 50–60°C. Then demonstrate Activity 3.7b in which learners measure the water temperature as it increases to boiling point. Discuss the changes that took place. What did learners observe, apart from the temperature increase? At the end of the activity get learners to answer questions 1–4 about their observations. They should also think about how scientists work, by repeating investigations until they are sure that their findings are consistent, in other words they get the same result each time.
- As an extension, you can get learners to use the results obtained in Activity 3.7b to draw a line graph. Alternatively, learners can complete Worksheet 3.7 which requires them to identify patterns in results and explain them. They should observe that in Mr Li's investigation the temperature rises faster.
- Exercise 3.7 in the Activity Book will allow learners to consolidate what they have learnt.

Notes on practical activities

Activity 3.7a
For the demonstration you will need:
- water
- a beaker or pan
- a hotplate or Bunsen burner.
Ask the learners to make drawings of what they observe. They should see bubbles forming in the hot water. These are bubbles of water vapour. They should also listen to the changes in sound that occur as the water heats up. Once the water has reached boiling point, learners should observe the cloud of condensing steam above the boiling water. Remind them that we only see the condensed steam, not the steam itself, which is invisible.
Learners can describe their observations orally in a class discussion about boiling. The boiling water forms bubbles. It feels warm. If you put your hand closer to the boiling water the condensing steam will feel very hot rather than warm. Steam comes from the boiling water.

Activity 3.7b
For the demonstration you will need:
- water
- a beaker or pan
- a hotplate or Bunsen burner
- a thermometer
- a digital watch, watch with second hand or stopwatch.

Learners should put their hands near the boiling water as steam can scald. Learners should take care when putting the thermometer in the hot water.

Check the thermometer to ensure that it is working. Get learners to take it in turns to measure the water temperature. This will help you to assess how well they are able to use a thermometer to read temperature. The learner reading the temperature should call out the reading so the rest of the class can record it in their data tables.

Measurements will depend on the amount of heat supplied by the heat source and the volume of water used. This is a set of possible results.

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>Water temperature in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (start)</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
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<td>6</td>
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<td>14</td>
<td>100</td>
</tr>
<tr>
<td>16</td>
<td>100</td>
</tr>
</tbody>
</table>
Internet and ICT

- The website: www.harcourtschool.com/activity/hotplate/index.html has an interactive demonstration of the measurement and graphing of the boiling and melting points of different substances.

Assessment

- Discuss answers to Exercise 3.7 in class and allow learners to check and correct their own work for self-assessment purposes.

Differentiation

- Lower achieving learners can be helped to improve their skills in reading a thermometer by means of peer tutoring. Get learners who are proficient in the skill to work with those less able to use a thermometer correctly.
- Higher achieving learners can do some research to answer the ‘Challenge’ question.

Common misunderstandings and misconceptions

- It is quite common for learners to think that water continues to heat up even after it has reached boiling point. Some learners also think that the amount of time that heat was applied affects the temperature, even after boiling point has been reached.
- Learners may also mistake the bubbles in the boiling water as air bubbles rather than bubbles of water vapour, and think that steam is a visible cloud of water vapour over boiling water. Steam is really the invisible water vapour formed when water boils. What we erroneously call ‘steam’ in everyday life is the droplets of water vapour condensing in the air as the steam cools.

Talk about it!

Evaporation happens when a liquid/water slowly changes to a gas at a low temperature. Only particles on the surface of the liquid become a gas. Boiling happens when a liquid/water changes quickly to a gas at a high temperature. Particles throughout the liquid (not just those on the surface) change to a gas.

Homework ideas

- Exercise 3.7 in the Activity Book.

Answers to Learner’s Book questions

1. a The water temperature increases until it reaches boiling point. It does not increase any more after that.
   b a line graph
2. a The answer will depend on the altitude you are at and the dissolved solutes in the water. Any temperature from 95–100 °C is normal boiling point.
   b Yes, if the water is boiled at the same height above sea level. Learners can find out by repeating the experiment a number of times.
3. No. The hottest particles became water vapour. The cooler ones left behind still had to heat up to boiling point so the heat energy was taken up by heating up the cooler particles. This meant that the temperature didn’t rise.
4. a Water vapour bubbles.
   b When water boils it changes from a liquid to a gas. The bubbles of water vapour gas form as the water gets hot enough and starts to change into a gas.

Answers to Activity Book exercise

Exercise 3.7

1. drawing B
2. evaporation
3. a In both processes liquid water changes into water vapour gas.
   b Boiling happens when water is heated to 100 °C. Evaporation happens at much lower temperatures.
4. a Beaker A – any temperature in normal room temperature range of about 20–40 °C.
   b Beaker B – 100 °C
Answers to Worksheets

Worksheet 3.7

1. The graph of Mrs Drop’s class results is steeper and the temperature reaches boiling point quicker than the graph of Mr Drip’s class results.

2. a. No
   b. The graph of Mr Drip’s class results is steeper and the temperature reaches boiling point quicker than the graph of Mrs Drop’s class results.
   c. Mr Drip gave the water more heat/used hotter burner or hotplate.

3. Bubbles form in the boiling liquid, steam forms and condenses in a cloud above the boiling water.

Topic 3.8 Melting

The main idea explored in this topic is that ice melts at a temperature of 0°C.

Learning objectives

- Know that the boiling point of water is 100°C and the melting point of ice is 0°C.
- Measure temperature.
- Recognise and make predictions from patterns in data and suggest explanations using scientific knowledge and understanding.
- Use observation and measurement to test predictions and make links.
- Interpret data and think about whether it is sufficient to draw conclusions.
- Present results in bar charts and line graphs.

Ideas for the lesson

- Begin by asking the class why they think solids such as ice and butter melt. How does heating affect the solids? If we leave a cube of ice and a cube of butter in the same place, which one will melt first? Why?
- You can then introduce the idea of melting point and explain that different solids melt at different temperatures. Butter melts at a higher temperature than ice.
- At what temperature do learners think that ice melts? Invite learners to think about their experiences. Would ice melt on a hot summer day outside in the Sun? What might a warm outside temperature be? Would ice melt in the room in which the learners are at this moment? What is the temperature of the room? Ask the class to make predictions about the melting point of ice.
- Learners can then do Activity 3.8, which requires them to measure and record temperature. It is interesting to note that the temperature of the ice will stay the same until all the ice has melted. Only then will it increase from 0°C.
- Learners can then answer questions 1 and 2 in the Learner’s Book which require them to identify a pattern in the results and think about how what type of graph would be best for presenting the results. Learners will also think about repeating measurements in order to gather enough evidence to form a conclusion about the melting point of ice.
- Ask learners if the melting point of ice will change if the ice melts faster. The answer is that it will not. The rate of melting will change, but not the temperature at which the ice melts.
- Get learners to look at their data tables again and answer question 3 in the Learner’s Book in which they make, explain and test predictions about the temperature of the melted ice.
- Ask learners at what temperature water freezes to become ice. They should be able to use their observations and measurements from Activity 3.8 to suggest a temperature value. Point out that for most substances,
the melting and freezing points are about the same temperature.

- In Worksheet 3.8a, learners draw a line graph of the results of melting ice. Remind learners how to plot points on the graph by placing a dot at the point on the graph grid where the measurements on the x and y axes meet for each temperature recorded.

- Worksheet 3.8b requires learners to measure temperature and use the data to draw two line graphs on the same set of axes. Learners should look for a pattern in their results. Ask them to look at the shape of the graph. Does the temperature change in a smooth, straight line in both beakers? Can learners explain this observation? What has caused the change in the pattern? Learners should use their graphs as a basis for their prediction about the effect of more salt on melting point.

Notes on practical activities

Activity 3.8

Each group will need:
- ice cubes
- beaker or jar
- thermometer
- digital watch, watch with second hand or stopwatch.

Learners should work in groups of 4 or 5.

Check the thermometers to ensure that they are working. The investigation works best with crushed ice. Tell learners to place the thermometer so that the bulb is sitting in the middle of the cup of ice, toward the bottom. It is important that the thermometer does not touch the sides or bottom of the cup and that the ice is tightly packed in the cup.

After the thermometer has been in the ice for a few minutes, learners should measure the temperature of their ice. The readings they take may be close to 0 °C, but may vary for several reasons.

The warmer air in the room can circulate in the air pockets between the pieces of crushed ice, which will cause the temperature readings to be higher. Higher readings may also arise because the thermometer was in contact with the sides or bottom of the cup, or it wasn’t buried deeply enough in the ice, or the learners may have held it out of the ice for too long before reading it.

Lower readings may occur because standard household freezers are generally kept at about −18 °C and the ice will also be that cold. In addition, some thermometers read differently, unless you are using a digital thermometer.

Ask each group to share their temperature readings. What readings did they find? The readings should be close to 0 °C. Were they all similar? What does this tell us about the temperature at which ice melts?

After 20 min, the temperature will have increased if all the ice has melted. The actual temperature will depend on the environmental conditions in your classroom. Once the ice is melted, the temperature of the water will increase until it reaches the temperature of the room.

Note that contrary to our instincts, the water temperature in the beaker will not increase while there is ice in the beaker. The warm room continues to add energy to the beaker, but all of that energy continues to go into melting the ice, rather than raising the temperature of the water. Once all the ice has melted, that energy can begin to increase the water's temperature.

Actual measurements will depend on the temperature of the surroundings. This is a set of possible results.

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>Temperature of ice in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>−2</td>
</tr>
<tr>
<td>1</td>
<td>−1</td>
</tr>
<tr>
<td>2</td>
<td>−1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>15</td>
</tr>
</tbody>
</table>
Unit 3 Teaching ideas

Worksheet 3.8b

Each group will need:
• ice cubes
• some salt
• two beakers
• a measuring spoon
• a thermometer
• a digital watch, watch with second hand or stopwatch.

Learners should work in groups of 4 or 5.

Check the thermometers to ensure that they are working. Put them in warm water and see the temperature rise and then put them in cold water to see the temperature drop again.

The investigation works best with crushed ice. You can crush the ice cubes by putting them in plastic bag and hitting them with a hammer or mallet.

Tell learners to place the thermometer so that the bulb is sitting in the middle of the cup of ice, toward the bottom. It is important that the thermometer does not touch the sides or bottom of the cup and that the ice is tightly packed in the cup.

After the thermometer has been in the ice for a few minutes, learners should measure the temperature of their ice.

Learners can try to predict what will happen when they add the salt. Learners should then sprinkle about a teaspoon of salt over the ice and record the temperature. There is quite a sudden drop in the temperature once the salt is added. What happens to the ice? (It becomes completely frozen.)

Adding salt lowers the melting point of ice. The greater the amount of salt, the lower the melting point. Sea water is about 3.5% salt and freezes or melts at about −2 °C. A 10% salt solution (90 ml crushed ice and 10 ml salt) makes ice melt at −6 °C, and a 20% (80 ml crushed ice and 20 ml salt) solution makes ices melt at −16 °C.

Assessment
- You can assess learners’ line graphs from Worksheet 3.8a using these criteria: Does the graph have a suitable heading? Is each data point indicated by an obvious, but not overly large dot? Are all data points correctly plotted? Are the data points correctly connected? Does the graph represent the data collected?

Differentiation
- Lower achieving learners can complete Exercise 3.8 in the Activity Book to help consolidate their understanding of melting.
- Higher achieving learners can do Worksheet 3.8b as an extension activity. They will need about 45 min to an hour to carry out the investigation and fill in the worksheet.

Talk about it!
Salt makes the ice melt at lower temperature, so although the air temperature may still be very low, the roads are not frozen.

Homework ideas

Worksheet 3.8a.

Answers to Learner’s Book questions

1 a The temperature increases until it reaches 0 °C. It stays at 0 °C for a few minutes then starts to increase again.
   b a line graph
2 a 0 °C
   b Do the experiment over again a few times.
   c Put it in a warmer place or heat the beaker.
3 a Predictions in the region of 25−30 °C are feasible, depending on room temperature.
   b Learners’ own answers.
4 When water goes from solid to liquid, we refer to melting point; when the change is from liquid to solid, it is the freezing point, but the temperature of the change is the same. Zero degrees Celsius is the temperature point of phase change in both processes. The two processes are the reverse of one another. The starting point of one process is the ending point of the other.

Internet and ICT
- The website: www.harcourtschool.com/activity/hotplate/index.html has an interactive demonstration of the measurement and graphing of boiling and melting points of different substances.
- The website: http://www.sciencekids.co.nz/gamesactivities/meltingpoints.html has interactive activities on melting points of different substances.

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Answers to Activity Book exercise

Exercise 3.8

1
After two minutes
After ten minutes

2 a It melted.
   b It melted because the ice was heated and gained enough energy to change the solid ice into liquid water.
   b 0°C
   c melting point
3 If all the ice has melted, learners can predict any temperature above 0°C.

Answers to Worksheets

Worksheet 3.8a

1 a a line graph

2 a 0°C
   b It changes from a solid to a liquid.
3 a Learners should predict a temperature of about 8−10°C.
   b See changes to graph.

Worksheet 3.8b

1 b The results obtained will depend on the amount of salt used and the ambient temperature. A set of possible results is given.

2 a Learners’ predictions will vary. These are possible answers.
   Beaker A: 0°C
   Beaker B: −6°C
   b Yes/ no, depending on the prediction made.
3 Beaker A: ice is melting.
   Beaker B: ice is still frozen.
4 b Beaker A: 0°C
   Beaker B: Approximately −5°C if one teaspoon (5 ml) of salt is added to 5 crushed ice cubes. (The answer will depend on the volume of ice used and the amount of salt added. Adding more salt will lower the melting point further.)
Unit 3 Teaching ideas

6  a In beaker A, the temperature of the ice increases over time. In beaker B the temperature of the ice drops when the salt is added and then starts to rise.
   b Salt makes ice melt at a lower temperature.

7  a The temperature will drop and the ice will stay frozen. Melted ice will re-freeze.
   b Yes/no, depending on the prediction made. If prediction was correct: The ice stayed frozen and the temperature dropped.

8  Salt makes ice melt at a lower temperature. No need to repeat investigation.

Topic 3.9 Who invented the temperature scale?

The main idea explored in this topic is the way scientists have used different ideas and evidence to develop different temperature scales.

Learning objectives

• Know that the boiling point of water is 100 °C and the melting point of ice is 0 °C.
• Know that scientists have combined evidence with creative thinking to suggest new ideas and explanations for phenomena.

Ideas for the lesson

• Ask learners to look at thermometers, or pictures of thermometers, such as the one in the Learner’s Book. Ask them to observe how the temperature degree readings are graded or divided.
• Explain that in order to measure anything, we need a scale to measure it with. When you want to know how tall you are, you use a measuring tape to measure your height. The scale that is used to measure height is metres. If you want to know how much you weigh, the scale used is kilograms. The scale we use for temperature is degrees (°).
• Then talk about the different temperature scales invented by Fahrenheit, Celsius and Kelvin. Learners can then answer Questions 1 to 4 about the different temperature scales.
• Exercise 3.9 in the Activity Book is a consolidation exercise.

Internet and ICT

• The website: www.physics4kids.com/files/thermo_scales.html gives a concise explanation of the three different temperature scales.
• The website: http://www.ehow.com/info_8327258_temperature-games-kids.html has ideas for games related to temperature.
• The website: http://www.enchantedlearning.com/science/temperature/ discusses the different temperature scales and explains how to do conversions between them. It also has additional activities and worksheets about temperature.

Assessment

• Do learners know the main differences between the temperature scales? Get them to check one another’s answers to questions 1–4 in the Learner’s Book and discuss the answers to any questions that they got wrong.

Common misunderstandings and misconceptions

• It is fairly common for learners of this age to think that heat and temperature are the same. You should explain that temperature is a measurement of the amount of heat energy in a substance or object.

Talk about it!

The Celsius scale is easiest to use. Learners’ reasons could include that it based on round numbers such as zero and 100.

Homework ideas

• Exercise 3.9 in the Activity Book.

Answers to Learner’s Book questions

1 Scientists needed to invent a temperature scale to make their investigations more accurate.

2  a Celsius gave values of 0° and 100° to the boiling points of water and melting points of ice.
   b He reversed the values and made melting point of ice 0° and the boiling point of water 100°.
3  a  To measure the temperatures of very cold things.
    b  ‘Absolute zero’ is the temperature at which particles do not move at all and everything including air freezes solid.

4  a  Both Kelvin’s and Celsius’ temperature scales have 100° difference between freezing and boiling points of water.
    b  Celsius’ scale starts at 0° which is the temperature at which water freezes and Kelvin’s scale starts at the temperature at which all particles have no energy and cannot vibrate.

Answers to Activity Book exercise

Exercise 3.9

1  a  Fahrenheit measures boiling point of water as 212°
    Celsius measures boiling point of water as 100°
    Kelvin measures boiling point of water as 373°

2  a  Fahrenheit 32°
    b  Celsius 0°
    c  Kelvin 273°

3  a

Answers to Learner’s Book questions

1  a  evaporation
    b  condensation
    c  melting
    d  freezing
    e  boiling

2  a  evaporation
    b  Her plants have a smaller surface area from which water can evaporate.
    c  Saria can put them in a cooler place, use a pot with a smaller opening/open surface so less evaporation will take place.

3  a  Water vapour condensing into drops of water.
    b  water
    c  condensation
    d  The water vapour cooled down and become liquid water.

4  A  evaporation
    B  condensation
    C  freezing
    D  melting

5  a  Ice cubes in B. They are in warm place and will heat up fastest.
    b  No. Ice melts at 0 °C. It just melts faster if it is in a warm place.
    c  Solid ice changes to liquid water.

Answers to Activity Book exercise

1  melts
2  freezes
3  evaporates
4  condenses
5  a  If you heat water to a temperature of 100 °C it reaches its boiling point.
    b  If you heat ice to a temperature of 0 °C it reaches its melting point.
    c  Liquid water forms steam when it boils.
    d  Ice forms water when it melts.
Worksheet 3.1

Investigate evaporation in other liquids

Name: ________________________             Date: ________________________

This is a practical activity, which you will have to plan carefully first.

Plan an investigation to answer the questions.

1. What will you measure or test?

________________________________________________________________________

2. What materials and equipment will you use?

________________________________________________________________________
________________________________________________________________________

3. What will you keep the same? How will you do this?

________________________________________________________________________
________________________________________________________________________

4. What will you change?

________________________________________________________________________
________________________________________________________________________

5. How will you make your test fair?

________________________________________________________________________
Plant hunt

Name: ________________________             Date: ________________________

What plants can you find outside the classroom?
Label the stem, leaves and flowers then draw how the roots might look.

Predict the results you will get.

_______________________________________________________________
_______________________________________________________________

Will you present your results as a bar chart or a line graph?

_______________________________________________________________

How will you collect enough evidence to test your prediction?

_______________________________________________________________
_______________________________________________________________

Draw a graph of your results

8 Do you have enough evidence to form a conclusion? Say why or why not.

_______________________________________________________________
_______________________________________________________________
_______________________________________________________________
Worksheet 3.3

Draw a graph of evaporation

Name: ________________________             Date: ________________________

In this activity, you will draw a graph, look for patterns and interpret results.

Lena and Ari measured evaporation from a puddle of rainwater one morning.

These are their results:

<table>
<thead>
<tr>
<th>Time on clock</th>
<th>Amount of water evaporated in ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.00</td>
<td>0</td>
</tr>
<tr>
<td>8.00</td>
<td>30</td>
</tr>
<tr>
<td>9.00</td>
<td>100</td>
</tr>
<tr>
<td>10.00</td>
<td>200</td>
</tr>
<tr>
<td>11.00</td>
<td>400</td>
</tr>
<tr>
<td>12.00</td>
<td>800</td>
</tr>
</tbody>
</table>

1. Draw a graph of their results.
2 a. How long did it take for 100 ml of water to evaporate?

b. How long did it take for 400 ml of water to evaporate?

c. How long did it take for 800 ml of water to evaporate?

3 a. Between which times was evaporation the slowest?

b. Between which times was evaporation the fastest?

4 a. What pattern can you see in the results?

b. Explain the pattern.

5 Would the puddle dry faster or slower on a windy day? Say why.
Worksheet 3.4

Separate salt and sand

Name: ________________________             Date: ________________________

In this practical activity, you will investigate how to separate salt from sand.

1 Mix 50 ml of salt, 50 ml of sand and 100 ml of water together in a jar. Stir the mixture.

2 Use the filter funnel and filter paper to filter the mixture into the container.

3 Place the container in a warm place for a day.

4 Predict what you expect to find in the container after a day.

5 Observe the container the next day. What do you see in it?

Questions

1 Why did you stir the mixture of salt, sand and water?

______________________________________________________________________________

______________________________________________________________________________

2 Why did you filter the mixture?

______________________________________________________________________________

______________________________________________________________________________

You will need:
- sand
- salt
- water
- filter paper
- a filter funnel
- a jar or beaker
- a shallow container
- a measuring cylinder.

Separate salt and sand

Name: ________________________             Date: ________________________

In this practical activity, you will investigate how to separate salt from sand.

1 Mix 50 ml of salt, 50 ml of sand and 100 ml of water together in a jar. Stir the mixture.

2 Use the filter funnel and filter paper to filter the mixture into the container.

3 Place the container in a warm place for a day.

4 Predict what you expect to find in the container after a day.

5 Observe the container the next day. What do you see in it?

Questions

1 Why did you stir the mixture of salt, sand and water?

______________________________________________________________________________

______________________________________________________________________________

2 Why did you filter the mixture?

______________________________________________________________________________

______________________________________________________________________________

You will need:
- sand
- salt
- water
- filter paper
- a filter funnel
- a jar or beaker
- a shallow container
- a measuring cylinder.
3  a  What was left behind on the filter paper?

b  What went through the filter paper into the container?

4  Why did you leave the container in a warm place for a day?

5  a  Was your prediction right? How do you know?

b  How did you separate the salt from the sand?

6  Name the solute and solvent in this activity.

   Solute:  
   Solute:  

7  Suggest two ways to obtain results more quickly.
Worksheet 3.6

Design a fresh water system

Name: ________________________             Date: ________________________

In this practical activity, you will be making a system to give you fresh water. You will have to apply your knowledge about evaporation and condensation in the water cycle.

Imagine that you are shipwrecked on an island. There is no fresh water on the island. The only water is seawater. You have with you:

- a plastic bag
- a jam jar
- a small bucket
- an elastic band.

Water! Water!
1. a. Design a system that will help you get fresh water from the sea.
   b. Make drawing of your design. Label the parts of the system to show what they are made from.

2. Explain how your system works to give you fresh water.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Worksheet 3.7

How fast does water boil?

Name: ________________________             Date: ________________________

In this activity, you will compare water temperatures, complete a line graph and look for patterns.

Mrs Martinez investigated boiling with her class. She heated water and measured its temperature. The class recorded these results.

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in °C</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Mr Li’s class carried out the same investigation. These are their results.

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in °C</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Both classes started drawing line graphs of their results.
Worksheet 3.7

1 Complete the line graphs.

2 a Are the line graphs identical? _________________________________________

   b What difference do you notice in the patterns of the two line graphs?
   _________________________________________________________________
   _________________________________________________________________
   _________________________________________________________________

   c Suggest a reason for this difference.
   _________________________________________________________________
   _________________________________________________________________

2 a What is the boiling point of water?
   _________________________________________________________________

   b Do the two line graphs support this conclusion? _______________________

   c How could you find out if water always boils at this temperature?
   _________________________________________________________________
   _________________________________________________________________

3 How would you know when the water boiled if you did not measure its
   temperature? Suggest two ways.
   _________________________________________________________________
   _________________________________________________________________
Worksheet 3.8A

Draw a line graph of melting

Name: ________________________             Date: ________________________

In this activity, you will draw a line graph and make a prediction.

Mrs Campbell’s class melted ice and measured its temperature. These are their results.

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in °C</td>
<td>-5</td>
<td>-4</td>
<td>-2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Draw the line graph.
2  a  Which temperature is the melting point of ice? _______________________
    
    b  What happens to ice when it melts?
    ________________________________________________________________

3  a  Predict the water temperature after 20 min.
    ________________________________________________________________
    
    b  Draw this temperature on your line graph.
Worksheet 3.8b

Investigate melting point

Name: ________________________             Date: ________________________

In this practical activity, you will investigate how salt affects the melting point of ice.

1  a  Put five ice cubes in each beaker. Label the beakers A and B.
   
   b  Measure the temperature of the ice in both beakers. Record your measurements in the table.

<table>
<thead>
<tr>
<th>Time in min</th>
<th>Beaker A</th>
<th>Beaker B</th>
<th>Beaker A</th>
<th>Beaker B</th>
<th>Beaker A</th>
<th>Beaker B</th>
<th>Beaker A</th>
<th>Beaker B</th>
<th>Beaker A</th>
<th>Beaker B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 0</td>
<td>10 10</td>
<td>15 15</td>
<td>20 20</td>
<td>25 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2  Sprinkle salt over the ice cubes in Beaker B. Leave the beakers to stand for 10 min.
   
   b  Predict the temperature in both beakers after 10 min.

   Beaker A: ______________________________________________________
   Beaker B:  ______________________________________________________
   
   c  Measure the temperature of the ice in both beakers. Record your measurements in the table. Was your prediction correct?

   _________________________________________________________________

3  What do you observe in both beakers after 10 min?
   
   Beaker A: ______________________________________________________
   Beaker B:  ______________________________________________________
4 a Measure the temperature in each beaker every 5 min for the next 15 min. Record your measurements in the table.

b At what temperature did the ice melt in the beakers?

Beaker A: ______________________________________________________

Beaker B: ______________________________________________________

5 Draw a graph of your results.

6 What pattern do you notice in the graphs? Suggest a reason for the pattern.