Chapter 2

Water

CONTEXT AREA

- Water is a special substance. It is common in our lives and essential for our survival. Rainy days stop us from doing many outdoor activities, but without the rain, plants and animals could not survive.
- Sadly, many people waste water and pollute water. Many of our environmental problems are due to pollution in water.
- Water is also a wonderful chemical, with many special properties. A study of water is a study of science. In this chapter we extend the study of science using water as the key.

PRESCRIBED FOCUS AREAS

4.2 uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena

4.5 describes areas of current scientific research

DOMAINS

KNOWLEDGE AND UNDERSTANDING

4.7 describes observed properties of substances using scientific models and theories

4.7.2 **b** describe the physical changes that occur during observations of evaporation, condensation, boiling, melting and freezing

4.9.5 **a** describe the water cycle in terms of the physical processes involved

SKILLS

4.14 follows a sequence of instructions to undertake a first-hand investigation

4.15 uses given criteria to gather first-hand data

4.19 draws conclusions based on information available

4.20 uses an identified strategy to solve problems

VALUES AND ATTITUDES

4.26 recognises the role of science in providing information about issues being considered and in increasing an understanding of the world around them

4.27 acknowledges their responsibility to conserve, protect and maintain the environment for the future

CONCEPTS

How to detect water	Use of a chemical test to detect water
Change of state	States of matter and changes
	States of water in the environment
Water as a solvent	Different solvents and solutions
	Solutions and suspensions
	Crystallisation as reverse of solution
Distillation	Distillation of water
	Changes of state of water in a distillation
Water—the big picture	Water supply
	The water cycle
Water treatment	How drinking water is purified
	Sewage and what happens to it
Fresh or salt	Experiments to find the difference
	Extension experiments involving water

2.1 How to detect water

Rainy days stop us from doing many sports and outdoor activities, but the water in rain also brings life. Water is needed by all living things. We need water for growing food, for drinking, in our homes, for parks and gardens, in pools and in factories. Most of the water around us is hidden. Fog is water in air. Our bodies are 70% water. There is a lot of water in foods. Even dry food like biscuits and bread have water in them.

How common is water? Which foods have water in them? Is there water in some chemicals? To find out we need some way of testing for water.

There are chemicals which are used to detect water. One of them is copper sulfate. We used copper sulfate crystals in the last chapter. The other chemical is cobalt chloride. It is dissolved and then soaked into paper. Water causes cobalt chloride in the paper to change colour.

When you are testing for water or any other substance, you must use clean glassware. In testing for water, make sure that the glassware you use is dry. If the colour changes, indicating that water is present, then we say that there has been a positive result. If there is no change, then there is a negative result. A negative result means that water is not present.

Fog obscuring road

EXPERIMENT

Aim: To test for water

It is not easy to test for water. It has no colour, taste or smell. Although water is common, it is often mixed with other substances. (Tasting is not a good idea. What if the water is mixed with a poisonous chemical?) Here are two simple tests for water.

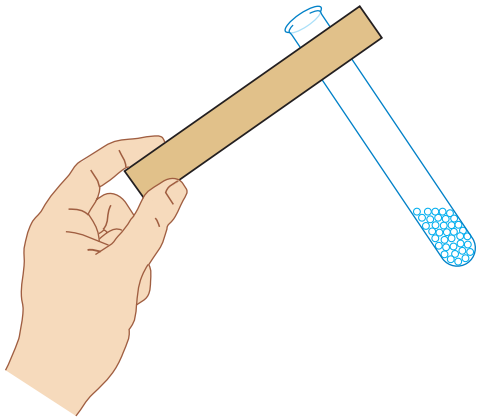
Test 1

Heat dry copper sulfate crystals in a test tube. Heating a test tube is a special skill. Follow the hints in the diagram before starting the experiment.

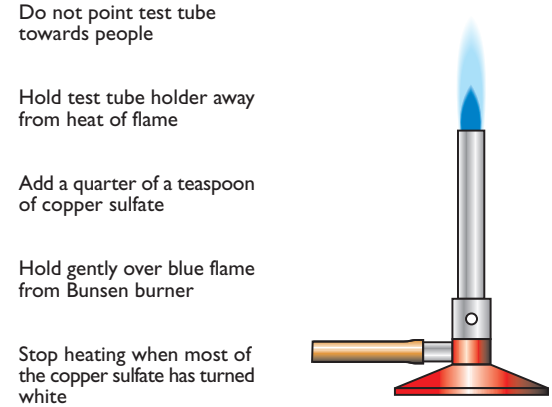
Warm the crystals gently, then heat them carefully until you notice some changes. Heat gently until the blue colour is gone. Did you see any drops of water on the inside top of the test tube? Where did the water come from?

Then turn the gas off, and rest the test tube in a test tube rack. When the test tube is cool, put one drop of water in it. What happens?

What happens if oil (not water) is put onto the cooled dry copper sulfate? Explain how this can test for water.



Heating dry copper sulfate crystals



Test 2

Your teacher will give you some paper that has been soaked in cobalt chloride. The paper will be pale pink. Place this paper on a gauze mat. Gently warm the gauze mat in the heat about 30 cm above the top of a blue Bunsen burner flame. This will dry the paper without burning it or your fingers. The paper will change colour.

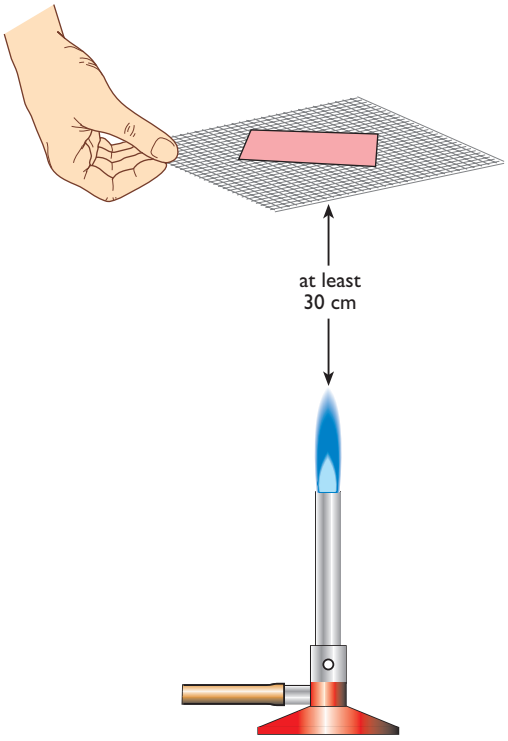
When the paper is dry, splash one drop of water onto it. What happens? Dry the paper again. Is the change reversible?

In your note book, describe two chemicals which can be used to test for water. What happens if there is a positive result? What happens if there is a negative result?

Use these water-testing chemicals to find which of the following foods and household chemicals have water in them. Cobalt chloride paper is the most convenient to use. Record your results in a table in your note book.

foods lemonade, cooking oil, raw potato, potato crisps, tomato, vinegar, apples, honey

household chemicals deodorant, window cleaner, liquid dishwashing detergent, methylated spirits



Drying cobalt chloride paper

CHECKPOINT:

COPY AND COMPLETE

Water is needed by all _____ things. We need water for growing ____, for _____, in our _____, for parks and _____, in _____, and in factories. Most of the _____ around us is _____. Our _____ are 70% _____.
There are _____ which are used to _____ water. One of them is _____ sulfate. The other chemical is cobalt _____. It is _____ and then soaked into _____.
If the colour changes, _____ that water is present, then we say that there has been a _____ _____. If there is no _____, then there is a _____ result.

QUESTIONS

1 Name two chemicals used to detect water. Which one is used as a solid? Which one is soaked into paper?

2 What is the meaning of a positive and a negative result?

3 Sometimes water is said to be hidden in foods and chemicals. Explain what this means.

4 Copper sulfate is also called bluestone. Why is this? Is it always blue?

5 What is the positive result in the test for water when:
a copper sulfate is used?
b cobalt chloride is used?

6 List the rules for heating a test tube with a Bunsen burner.

7 Humidity is a measure of the amount of water in air. How could you show that air contains water?

2.2 Change of state

If you put water in the freezer of a refrigerator, it turns into ice. Is ice still water? The answer is yes. Ice is solid water. It has changed from a liquid we call water into a solid we call ice. When you boil a beaker of water, some of the water turns to a gas. If you boiled the water long enough, all the water would turn into a gas. We say that the water has vaporised or evaporated. The beaker would boil dry.

Ice, water and gas are different forms of the same substance called water. These are the states, or phases, of water. All substances have three states, which are called the states of matter. The three states of matter are solid, liquid and gas.

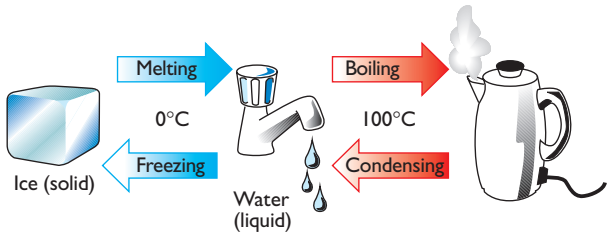
When you boil the kettle or electric jug, or remove a tea bag from a cup of hot water, some water evaporates. It soon appears as steam. Steam is made of tiny droplets of water floating in the air. You can see the tiny droplets if you look closely. Steam is really a liquid, with drops so small that they can float in the air. After a while, the steam evaporates into a gas.

Steam from tea bag

Each change in state is given a name. When water boils, the liquid water changes into a gas. This change is called boiling or vaporisation. When gas cools it can turn into liquid water. This change is called condensation. For water, boiling and condensation both occur at 100°C. When ice melts, it turns into liquid water. This change is called melting. When water turns into ice, the change is called freezing or solidification. Water begins to freeze when the temperature falls below 0°C and ice melts when the temperature rises above 0°C.

There is one other unusual phase change. Sometimes ice can evaporate without melting. The solid turns directly into a gas. This change is called sublimation. Dry ice, which is solid carbon dioxide, and iodine are other solids which sublime.

Water condenses on a cold surface. Some examples are the dew on the ground in the morning, or frost on a car parked outside. Water can also condense in the air. Storm clouds contain droplets of water liquid. Some clouds, such as cirrus clouds (sometimes called mare's tails), consist of crystals of ice.



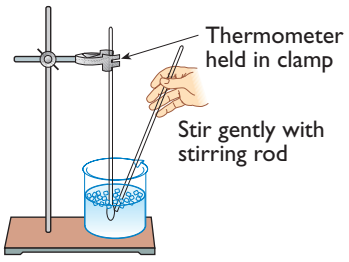
Changes of state for water

EXPERIMENT

AIM: To measure the melting point of ice

Mix some crushed ice with a small amount of tap water in a beaker, and stir it with a stirring rod. (Do not stir with a thermometer. The bulb on the bottom of a thermometer is thin and will break easily.) Record the temperature of the melting ice.

Confirm that the melting point of water is 0°C. Write a report of this experiment, like you did in Activity 1.6.



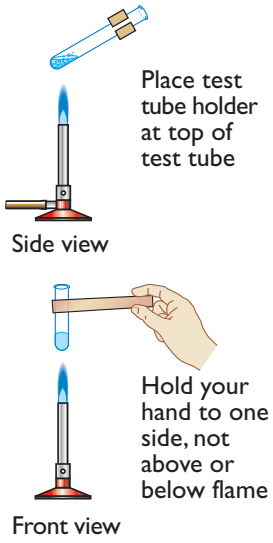
Measuring the melting point of ice

Heating a test tube

It is easy to boil water in a test tube. The small volume of water boils quickly. But be careful! Heating a test tube is an important skill, but it can be dangerous. It is essential to follow these rules:

1 Never fill the test tube more than one third full. This is important if you are heating water. With heating solids, a quarter of a teaspoon is best.
2 Hold the test tube in a test tube holder. Do not let the holder catch fire or smoulder.
3 Do not point the test tube at anyone.
4 Lie the test tube over at an angle of 60°.
5 Heat it gently, high up in the flame, then slowly lower it until it is near the top of the blue flame.
6 Don't keep heating the test tube after all the water has evaporated.
7 Move the test tube around in the flame. Heat the test tube evenly.

Test tubes are just that. They are a tube used to test a small amount of substance. Do not overfill test tubes. Small test tubes are best.



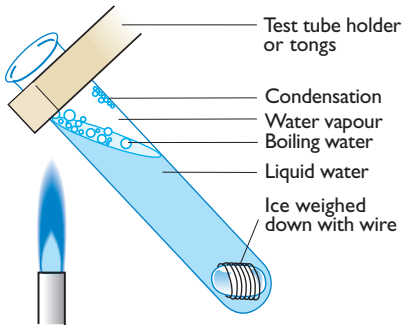
Heating water in a test tube

EXPERIMENT

Aim: To boil water in the presence of ice

Boil some water in a test tube. Observe the gas leaving the test tube, then the steam which forms when the gas turns to tiny drops of water. The steam then evaporates. Be careful. Boiling water and steam are both hot and can scald (burn) easily.

Obtain an ice cube that will fit into a test tube. Wrap copper wire around it, so that the ice cube will sink in water. Pour tap water into a test tube until it is one-third full, drop in the ice cube with the wire around it, and gently heat the water at the top of the test tube. (With the ice cube in, the test tube should be half to two-thirds full.) Are you skilled enough to have ice and boiling water in the same test tube?



Ice and boiling water in the same test tube!

CHECKPOINT:

COPY AND COMPLETE

Ice, water and gas are different _____ of the same substance called _____. These are the _____, or _____, of water. The three states of matter are _____, _____ and ___. Steam is really a _____, with drops so _____ that they can _____ in the air. After a while, the steam _____ into a gas.
Each change in _____ is given a name. When water boils, the _____ water changes into a ___. This change is called _____ or _____. When gas cools it can turn into _____ _____. This change is called _____. When ice melts, it turns into _____ water. This change is called _____. When water turns into ice, the change is called _____ or _____.

QUESTIONS

1 Name these changes of state.
  a solid to liquid
  b liquid to gas
  c liquid to solid
  d gas to liquid
  e solid to gas

2 What is meant by the letters mp and bp? What changes in state do they refer to?

3 What are the six rules for heating a test tube?

4 What is the state of water in these substances?
  a iceberg
  b dew on the ground
  c frost on a winter morning
  d invisible water in the air

5 Water is present in the air as a gas. It condenses to form clouds. Describe an experiment you could do to show that invisible water gas is in the air.

6 In very cold areas, wet clothes on a clothes line can freeze. Then they will dry without getting wet again. What is happening?

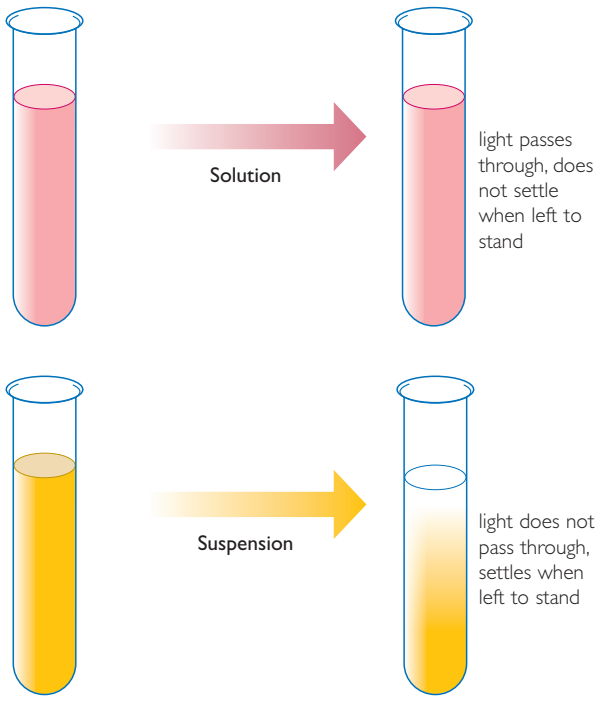
2.3 Water as a solvent

A liquid that dissolves substances is called a solvent. Water is a good solvent. Methylated spirits is a solvent which dissolves the ink in most felt-tip pens. Turpentine is a solvent which dissolves some plastics and paints.

The substance that is dissolved is called the solute. In a cup of coffee, the solute is the coffee. If sugar is added, it is also a solute.

A liquid made up of a solvent and a solute dissolved in it is called a solution. Sea water is a solution. It is made of salt dissolved in water. Lemonade is a solution of sugar and carbon dioxide gas dissolved in water. The iodine solution you might put on cuts is iodine dissolved in methylated spirits.

Some substances do not dissolve. They are said to be insoluble. Insoluble substances are glass, chalk, steel, sand and nylon. Sometimes a substance is soluble in one solvent but insoluble in another solvent. For example, grease is soluble in petrol but insoluble in water.



The difference between a solution and a suspension

When you shake an insoluble substance in water, it becomes mixed with the water. It does not dissolve. This sort of mixture is called a suspension. A suspension can be filtered, but a solution cannot. (Look back to Activity 1.5.) If you make a solution and leave it undisturbed, it will not change. If you make a suspension and leave it, the insoluble substance will either settle to the bottom of the container or float to the top.

DEMONSTRATION

AIM: To compare solutes and solvents

Your teacher will show you some solvents and solutes. Copy the table into your note book, and fill it in to show which solutes are soluble in which solvents.

SOLUTE	SOLVENT		
	Water	Methylated spirits	Turpentine
salt			
iodine			
sugar			
coffee powder			
cooking oil			
copper sulfate			

Discuss these questions with your teacher. Which solvent would you use to dissolve margarine? Grease on a motorbike engine? Smear marks on a mirror?

Coffee powder and sugar are the solutes in this cup of coffee

EXPERIMENT

AIM: To observe solutions and suspensions

Different substances can be tested for their solubility in water. Place a small amount of each of these powders into a separate test tube:

- bath salts
- washing soda
- cream of tartar
- talcum powder
- starch.

Add 5 mL water to each tube and mix by gently swirling the tube, to find out if each powder is soluble in water. Record your results in a table like the one to the right.

When an insoluble substance is mixed with water, it does not dissolve. It forms a suspension. You can also form a suspension by mixing some soluble substances. Pour each pair of these solutions into a test tube:

- sodium carbonate and calcium chloride
- sodium sulfate and barium chloride.

Mix the solutions gently and describe the suspensions that you observe. Barium chloride should be reacted with excess sulfate solution before being discarded in the sink.

Powder tested	*Soluble in water (✗ or ✔)*

Crystallisation

As you read in section 1.7, the process of undissolving a solute is called crystallisation. As the solvent evaporates, the solute is left behind. The solute mostly appears as crystals.

Crystallisation can happen on a large scale. Salt is obtained from sea water by evaporating large amounts of water. Sea water flows into shallow lakes, which are then closed off. The sun evaporates the water, leaving salt behind. This is done mainly in dry areas, where it is not cloudy and it doesn't rain much. The salt is cleaned before we eat it. Most of the salt produced in Australia is used in factories for making chemicals, including chlorine and sodium hydroxide.

The commercial production of salt

CHECKPOINT:

COPY AND COMPLETE

A _____ that dissolves substances is called a _____. Water is a _____ solvent. The substance that is dissolved is called the _____. A _____ made up of a _____ with a solute _____ in it is called a solution. Some substances do not _____. They are said to be _____.

The process of undissolving a _____ is called _____. As the solvent _____, the _____ is left behind. The solute mostly appears as _____. _____ can happen on a large scale. Salt is obtained from _____ water by _____ large amounts of water.

QUESTIONS

1 Explain which is the solute, solvent and solution when a cup of coffee is made from instant coffee powder.

2 Name three useful solvents mentioned in the text.

3 Service stations and car part shops sell products called degreasers. They dissolve grease and oil from around engines. What types of solvents would be in them?

4 Is it true that the ocean is the biggest solution in the world? Explain.

5 Explain why you can filter a suspension, but not a solution.

6 Which of these substances are soluble in water: wood, salt, sugar, sand?

7 Use your own knowledge of solubility (see demonstration) to propose a method for separating iodine crystals from salt crystals.

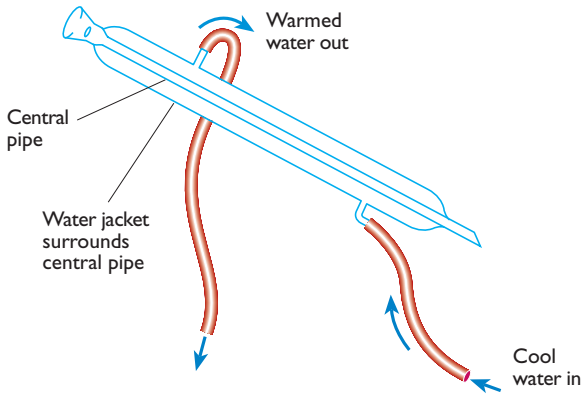
2.4 Distillation

When you crystallise a solution of copper sulfate, blue crystals are left behind. The water evaporates and is lost to the atmosphere. What if you want the water? How can you obtain pure water from a solution?

Filtering is not an option, as the solute and water both pass through the filter paper.

There is a way to obtain clean water. It is called distillation. Distillation is the process in which a solution is boiled and the steam is collected. The steam is then cooled and turned back into liquid water. This water is pure and is called distilled water.

Distillation is an important process for purifying water. The water mixture is heated with an electric hotplate or Bunsen burner. The vapours are cooled using a Liebig condenser. This condenser was invented by a German chemist called Justus von Liebig. A Liebig condenser relies on tap water to cool the steam and gas back into a liquid. The cooling water surrounds the inner pipe carrying the steam, gas and distilled water.



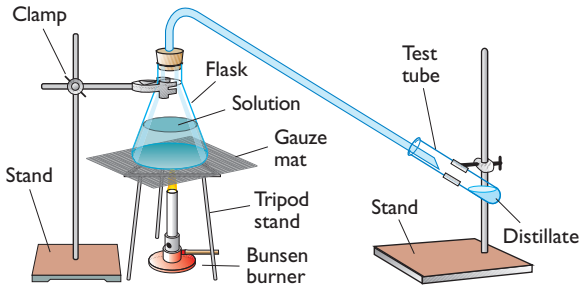
A Liebig condenser

Distillation is very important for purifying substances. Diesel fuel is called distillate because it is purified from crude oil by distillation. Distilling ocean water to obtain pure drinking water is important on cruise ships. Removing the salt from sea water to obtain pure water is called desalination.

EXPERIMENT

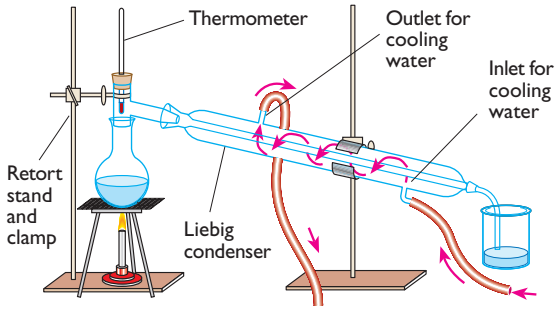
AIM: To perform distillations

The simplest way of distilling a mixture is to use a flask connected to a test tube by a glass tube. The glass tube acts as a condenser. It is cooler than the vapour, so it condenses the vapour into a liquid. Care is needed to keep the solution boiling very gently.



Experiment using a distillation flask

Another way of doing a distillation in the laboratory is to use a Liebig condenser. This condenser is a part of a special kit. The pieces of glassware fit together exactly. Petroleum jelly, paraffin or grease stops the glass surfaces from sticking together. There are no leaks when the pieces fit correctly. This glassware is expensive and fragile, so be careful.



Distillation using a Liebig condenser

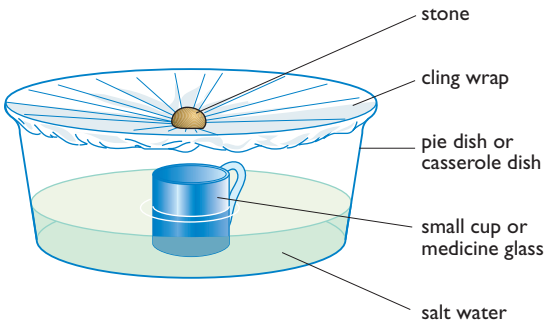
Your teacher will give your group a distillation flask. Put some copper sulfate into the flask and dissolve it. Set up your equipment as shown in the diagram and heat the flask gently until about half of the solution has boiled away; then stop heating.

Other types of distillation

There are other types of distillation. One is called fractional distillation. This separates two liquids that are mixed together. An example is water mixed with methylated spirits. Water boils at 100°C, and methylated spirits boils at 78°C. When the mixture is heated to 78°C, the methylated spirits will boil, leaving most of the water behind.

Air can be separated into its components by fractional distillation. Air is cooled until it liquifies (turns into a liquid). The liquid air is then slowly warmed, and the different gases boil off at different temperatures.

Distillation can also work using the Sun's energy. The diagram to the right shows a simple way to obtain clean drinking water.



Distillation using pie dish

CHECKPOINT:

COPY AND COMPLETE

Distillation is the process in which a _____ is _____ and the _____ is collected. The steam is then _____ and turned back into _____ _____. This water is ____ and is called _____ water.
A Liebig _____ relies on ___ water to cool the _____ and ___ back into a _____. The _____ water surrounds the inner ____ carrying the steam, gas and distilled water.
Distillation is very important for _____ substances. Diesel fuel is called _____ because it is purified from crude oil by _____. Distilling _____ water to obtain pure _____ water is important on _____ ships.
Removing the ____ from ___ water to obtain pure water is called _____.
There are other types of _____. One is called _____ distillation. This separates two liquids that are _____ _____. An example is _____ mixed with _____ _____ . Distillation can also work using the _____ _____.

QUESTIONS

1 What is meant by distilled water?

2 What is the easiest method to obtain the following pure substances from these mixtures?
   a clear water from a cup of tea (a solution)
   b clear water from a suspension of chalk
   c water from lemonade
   d salt from water

3 Compare the difference in meaning of these words. Write a sentence with both words in it which clearly shows the meanings.
   a condense, condenser
   b vapour, vaporise
   c distil, distillation

4 What is desalination? Why is it important in some areas of the world?

5 What are the changes in state which happen during a distillation? In your explanation, use the words condensation, liquid, vapour and vaporisation. The words may be used more than once.

6 Describe a Liebig condenser, and how it works.

7 When you perform a distillation (like in the experiment), what happens to the solute?

8 If you were stranded in the desert, how could you use plastic and the Sun's energy to obtain fresh water?

9 A famous English poem is called *The Rime of the Ancient Mariner*, by Samuel Taylor Coleridge. It is the story of an old man sailing a boat across the ocean. A popular version of its most famous lines are:

   Water, water every where,
   And not a drop to drink.

   a What do these two lines mean?
   b How could the ancient mariner have solved his problem?

2.5 Water—the big picture

Water is vital for life. Every living thing relies on water to stay alive. Most of the world's water is in the oceans. This water has salt dissolved in it. The rest of the world's water is also impure. It contains dissolved minerals from the soil, and microorganisms. Some water is polluted and cannot be used for drinking. How do we get clean water for washing food, showering and brushing our teeth?

Water supply

Water supply is the name given to the system of pipes which carry water to our homes, schools and offices. Water is collected in dams, or pumped from a river into a dam. Dams store water for later use, especially in the summer when the demand for water is large.

Each day a town or city uses a large volume of water. Water has to be treated and purified. Purification means making the water pure. To do this, clay and mud are removed and microscopic life in the water is killed. Water supply pipes are located underground, and smaller pipes run from these to each house and home unit.

Water is a valuable and limited resource. Yet many people waste water by having leaking taps, hosing paths and driveways too often, or leaving the basin tap running while cleaning their teeth. Saving water ensures a better supply during drought, and reduces the need for new dams or enlarging existing dams. This is good for our environment. The complete process of water supply is shown in the diagram below.

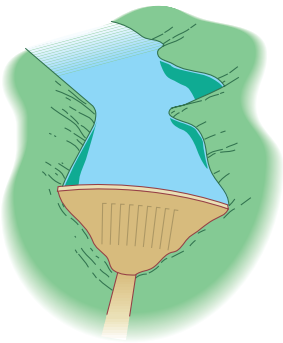
The water cycle

The fresh clean water that you drink has been used before. Many times before. The water in your tap has been in the bodies of dinosaurs, in the ocean and in a thunderstorm. How can water be used over and over again and still be clean?

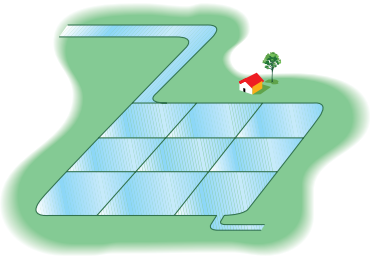
Water evaporates from lakes, rivers, oceans and land, and from plants. Only pure water evaporates, and it condenses into rain. (Over cities and factories the pollution can become dissolved in rain, snow or fog. This makes acid rain.)

The water which has been evaporated—from land, streams, lakes and oceans—forms clouds. Clouds join and grow and produce rain. The rainwater flows into drains and streams, back to the lakes and oceans. There is a constant movement of water. Water moves from rain to water vapour to clouds to rain again. This is called the water cycle. It is shown in the diagram on page 39.

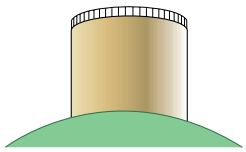
The water on the Earth is essential for living things to stay alive. Water also forms the landscape we see every day. Water is needed in many factories. Water can also provide us with energy to make electricity. These uses of water are explored in later chapters of this book.



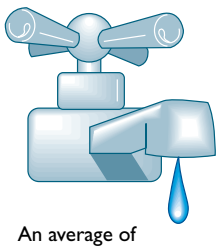
Water from rain and runoff is collected in dams and stored.



Water is pumped through long pipes to treatment works, where the water is purified.



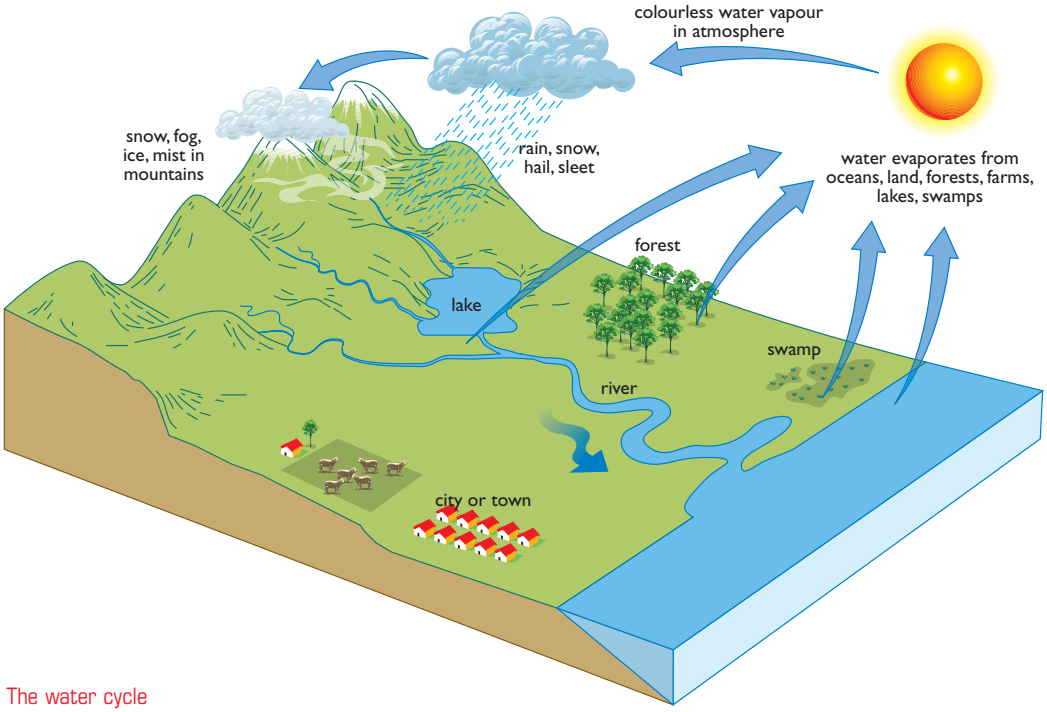
Drinking water is stored in reservoirs until it is used in homes, schools and factories.



An average of 1815 million litres of water are used in Sydney every day. Industry and homes are the biggest users.

How water is supplied to towns and cities

Water is so important that the layer of water on Earth has a special name. It is called the hydrosphere. The hydrosphere includes the ice and snow on the top of mountains, the water in lakes and rivers, the underground water, and all the water in the oceans.



The water cycle

CHECKPOINT:

COPY AND COMPLETE

Water is _____ for ____. Every living thing _____ on _____ to stay alive.
Water _____ is the name given to the _____ of _____ which carry water to our _____, _____ and offices.
Water is _____ in dams, or pumped from a _____ into a ___.
Water has to be _____ and _____. Purification means making the water ____. To do this, ____ and ___ are removed and _____ life in the _____ is killed.
The _____ _____ water that you drink has been used _____. There is a constant _____ of water. Water moves from ____ to _____ _____ to _____ to ____ again. This is called the _____ _____.
Water is so important that the _____ of _____ on _____ has a _____ name. It is called the _____.

QUESTIONS

1 Why does water have to be purified?

2 Water in the environment exists as rain, dew, snow, fog and other forms. Some of these are shown in 'The water cycle' diagram above. List as many forms of water as you can, and describe its state and location.

3 What is meant by water supply?

4 What are the changes in the state of water as it melts from ice at the top of a mountain, flows to the ocean, and becomes a part of a cloud?

5 Which parts of the water cycle change the state of water from:
a liquid to gas?
b gas to liquid?
c liquid to solid?

6 Which parts of the water cycle are like evaporation and condensation?

7 Why is rainwater pure (when there is no pollution)?

8 Part of the water cycle does not operate at night. What part is it, and why?

9 Some people have said that the planet Earth should be called the planet Water. Why is this?

10 When you dig a deep hole, it often fills with water. Where does this water come from? What is this water called?

2.6 Water treatment

Water is a valuable resource. It is needed by all parts of our society. How clean is the water we drink? And what happens to the water when we are finished with it? Water must be cleaned and reused if we are to have enough.

The aim of water treatment is to make water that is clean, safe and pleasant to drink.

Drinking water

The water we get from taps has been treated to make it safe. It has been filtered to remove solids, and treated with chlorine or ozone to kill microscopic living things.

One microorganism that is sometimes present in poorly treated water is cryptosporidium. It is a parasite which is found in the water supplies of some cities around the world. It exists in water as microscopic eggs called oocysts. These eggs can survive for over a year in water or the ground. The eggs hatch in the intestines of animals, including humans, and four tiny sporozoites burrow into the wall of the intestines. There they grow, reproduce and produce millions of eggs. And make you sick. The nausea and diarrhoea can last for days or weeks.

Fluoride is added to the water of some cities and towns. Small amounts of fluoride—about one part in a million parts of water—were added to water in many cities around the world. The reason is to improve the health of children's teeth. Now some people have doubts about the long-term effects of fluoride on people's health.

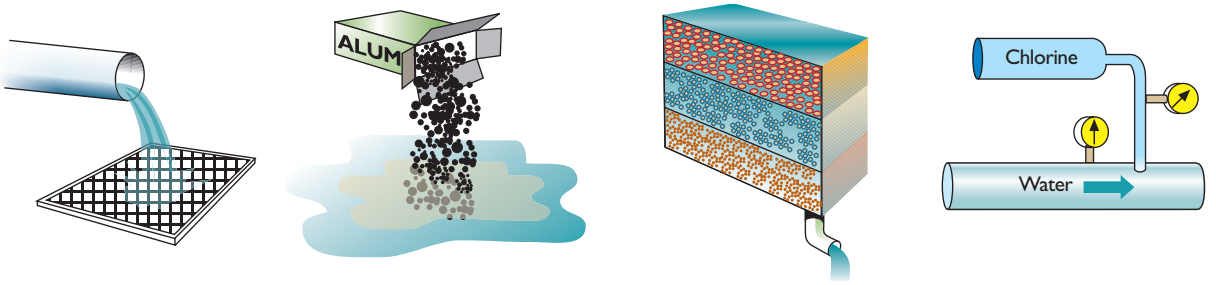
Sewage water

Every time you flush the toilet, or pull the plug out of the sink or bath, or have a shower, or wash the dishes, the dirty water flows away. This water is called sewage. Sewage contains human waste, food scraps, oils, dishwashing detergents and soap. This mixture contains many chemicals and disease-causing organisms.

Sewage has to be treated, or purified, before it is released into rivers or the ocean. Sewage is dangerous to the environment and living things because:

- it contains disease-producing bacteria and viruses
- it contains chemicals called nutrients, which act as fertilisers and cause plants to grow
- it uses up oxygen in the water, so that fish and other animals that live in the water die
- oils cover the top of the water, stopping air from entering and leaving the water
- it produces smells and odours.

Sewage must be treated to make it safe before it is released into the environment or reused. The first step in sewage treatment is called primary treatment. The sewage water is filtered, then allowed to stand in ponds. Most of the suspended matter sinks to the bottom of the ponds. When the water is drained away, the sludge can be removed. All of the dissolved chemicals remain in the water.



Water is passed through sieves to remove fish, sticks and water plants

Alum causes particles too small to filter to clump together. The water becomes a suspension.

Layers of gravel and sand act as a filter to remove all solids.

Chlorine is added to disinfect water. Microscopic living things are killed.

The stages involved in drinking water treatment

Sewage sludge

Sewage aeration

The second step in the treatment of sewage is called secondary treatment. This stage removes the chemicals which have come from living things. The sewage water is stirred and has air bubbled through it. This air helps bacteria in the sewage water consume these chemicals. The solution that remains is colourless and odourless, but still has many chemicals dissolved in it.

The third step is called tertiary treatment. All the soluble chemicals have to be removed. This is done by adding other chemicals and filtering, or by letting controlled amounts of water plants grow in the water.

The final stage in water treatment is to disinfect the water. This means killing all the microscopic life in the water. Chlorine gas is usually used; ozone is also used as a disinfectant. The water is then pure, clean, and ready for release into streams or oceans. It is even suitable for drinking. Each step in the process is monitored (measured) by a technician.

CHECKPOINT:

COPY AND COMPLETE

The aim of water treatment is to make _____ that is _____, ____ and _____ to drink.
The water we get from _____ has been _____ to make it ____. It has been _____ to remove _____, and treated with _____ or _____ to kill _____ _____ things.
Fluoride is added to the _____ of some _____ and _____. The reason is to improve the _____ of _____ _____.
_____ contains human waste, ____ scraps, ____, _____ detergents and ____. This _____ contains many _____ and disease-_____ _____. Sewage has to be _____ before it is _____ into _____ or the _____.
The final stage in water _____ is to _____ the water. This means _____ all the _____ life in the _____.

QUESTIONS

1 What is the meaning of these terms: water treatment, sewage, disinfect, monitor, nutrients, cryptosporidium?

2 What is done to make our drinking water clean before we drink it?

3 What is in sewage water which makes it so dangerous?

4 Why is water treatment needed? Outline the stages in water treatment.

5 Outline the stages in sewage treatment.

6 Why do swimming pools smell of chlorine? Why is it added to pools?

7 Some towns and cities have fluoride added to their drinking water. What is the purpose of the fluoride?

8 When sewage is added to a river or lake, the animal life and then plant life dies. Why does this happen?

2.7 Fresh or salt?

There are many ways of testing water to find whether it is salt or fresh. This is because salt water and fresh water have different properties. These different properties form the basis of the tests and experiments in this activity.

Here are some experiments to try. As you work through these activities, write your observations and results in your note book.

EXPERIMENT

AIM: To compare the difference in boiling points of fresh water and salt water

Boiling point should really be called boiling temperature. Boiling point is the temperature at which water changes from a liquid to a vapour. Pure water boils at 100°C, and salt water boils at a higher temperature. Record in your note book the boiling point of fresh water and salt water.

DEMONSTRATION

AIM: To test for the presence of salt in water

The big difference between salt water and fresh water is salt. There are a variety of chemicals we can use to test for salt.

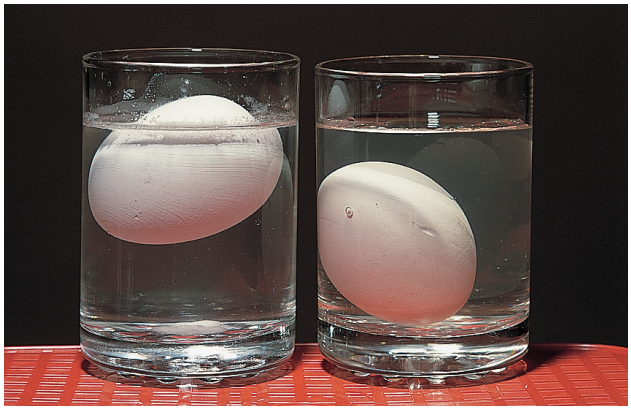
Tip a small amount of salt water and fresh water into separate test tubes. Test for salt by adding one drop of a chemical, like silver nitrate. Salt causes silver nitrate to go milky. Record in your note book what happened in this test for salt.

EXPERIMEN

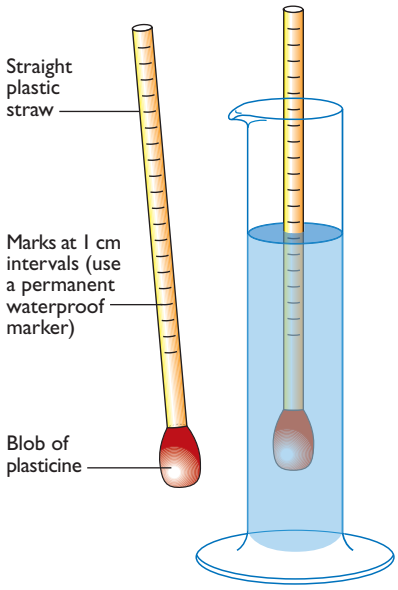
AIM: To compare how objects float in fresh water and in salt water

Density is a measure of how many atoms are squashed into a space. Fresh water has only water in it, but salt water has salt and water in the same space. So salt water should be heavier and thicker. We say it is denser. The easiest way of measuring the density of a liquid is by seeing how something floats in it. Eggs float at different depths in salt water and fresh water.

A hydrometer is a device that floats in liquids. It floats at different heights in liquids of different densities. Use the illustration to make a hydrometer from a straw and plasticine. Draw in your note book how the hydrometer floats in fresh water and in salt water.



Eggs floating in fresh water and in salt water

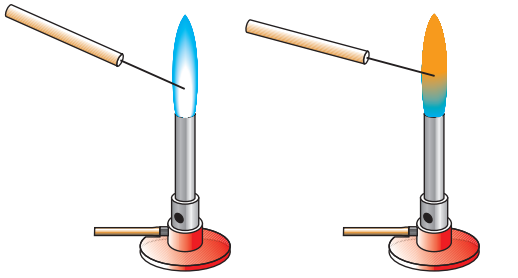


Making a hydrometer

DEMONSTRATION

AIM: To compare the flame test for fresh water and salt water

When some atoms are heated, they make particular colours. The sodium atoms in salt make an orange colour. In your note book, write down what happened for the flame tests shown below.



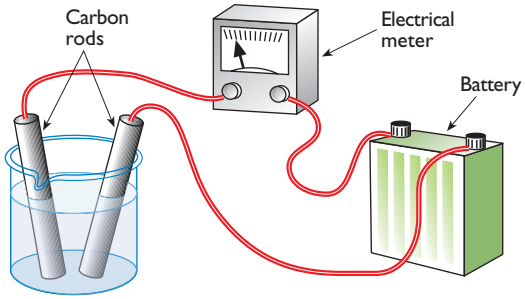
The flame test for salt

EXPERIMENT

AIM: To compare the electrical conductivity of fresh water and salt water

Pure water does not conduct electricity, but salt water does. Even the tiniest amount of salt (or dirt) causes the water to carry electricity. This is why you should never use an electric appliance when the floor, or you, are wet.

Small electronic meters can tell us how much salt is in water by measuring how much electricity the water carries. Set up the following experiment, with your teacher's help.



Testing for salt with electrodes

Write in your books what you did; draw a diagram of the equipment you used and the results you obtained.

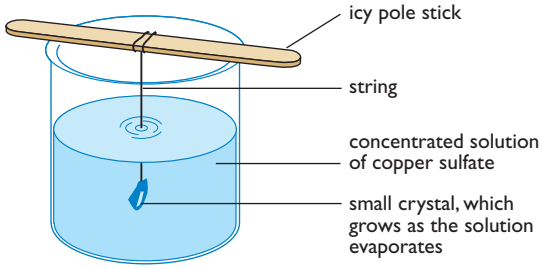
A digital conductivity meter

EXTENSION EXPERIMENT

AIM: To grow crystals of copper sulfate

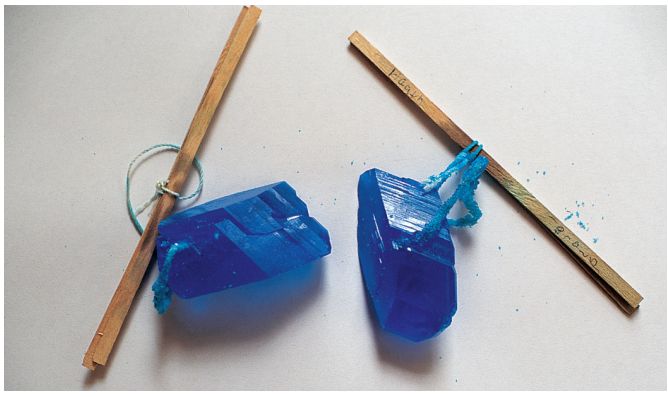
After you have finished the other activities in this chapter, your teacher may let you start on this additional activity. Check with your teacher before you start.

Slow crystallisation makes big crystals. Very slow crystallisation makes very big crystals. How big are the biggest crystals that your group can grow? The illustration shows how to grow large crystals.



A way to grow large crystals

Set up this experiment. The solution of copper sulfate should be concentrated, so that it is deep blue. The string should be clean and made of cotton or wool, not something slippery like nylon. After a week or so, crystals will grow on the string. Scratch off all the crystals except one, and replace the string into the solution. Let this one crystal grow. Scratch off any others about once a week.



Large copper sulfate crystals

Review and Research

Review Questions

These questions check what you have learnt from the notes and experiments in this chapter. Write complete answers in your note book.

1 Are the following statements true or false?
- a The three states of matter are solid, liquid and gas.
- b Clouds are made of water.
- c Ice melts at 100°C.
- d Steam is made of tiny droplets of water.
- e Sand is a soluble solid.
- f Crystallisation and distillation are the reverse of each other.
- g Slow crystallisation produces small crystals with a regular shape.
- h A solvent dissolves a solute to make a suspension.
- i People in cities drink stored and treated rainwater.
- j Water treatment means using water for cleaning dirty buildings and cars.
- k Blue-green algae live in water containing a lot of nutrients.
- l Adding sewage to a river is good because of the nutrients in sewage.
- m Bacteria are very important in converting sewage into clean water.
- n Snow, ice and hail are forms of solid water.
- o Most of the world's water is in the oceans.

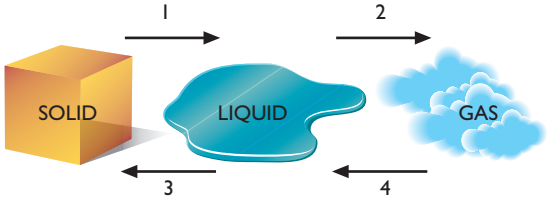
2 What is the state of water produced when:
- a ice melts
- b water evaporates
- c water freezes
- d steam condenses

3 Say whether each of the following is a solid, liquid or gas. Where or when are you likely to find each?
- a snow flake
- b dew
- c fog
- d frost
- e hail
- f rain
- g mist
- h vapour in air
- i cloud
- j steam

4 Dry ice is a solid which evaporates without melting. What is this change called?

5 What are the changes in state of water which happen to water in the following experiments?
- a crystallisation
- b distillation

6 Name the changes in the diagram labelled 1, 2, 3 and 4.



7 What is the difference between these words:
- a vapour and vaporise
- b melt and freeze
- c condensation and evaporation
- d condensation and distillation

8 Draw a Liebig condenser. Label the water jacket, the inner pipe and the distillate.

9 The photograph below shows a cloud forming above the chimneys of the Eraring Power Station in New South Wales on a still winter morning. Explain how and why the cloud forms.

A cloud forming above a power station

10 Sam wanted to find out if there is water in salad dressing. His teacher gave him some coloured paper. There was a chemical soaked into the paper. If the colour changed it would indicate a positive test. When Sam tested the salad dressing, the colour changed from blue to pink.
- a What does a 'positive test' mean?
- b Does this result mean that water is in salad dressing?
- c What is the chemical substance that has been soaked into the paper?

11 Draw a diagram of the water cycle. Label it with names and an arrow showing which way the water moves.

12 The water in our taps has been treated before we use it. What does treated mean? Explain the steps and reasons for this treatment.

13 What substances are contained in sewage? Why is sewage treated before it is allowed to drain into rivers or the ocean?

14 a What are the melting points and boiling points of water, measured in degrees Celsius?

b What is the state of water at each of the following temperatures: –50°C, 50°C, 150°C?

15 Copper sulfate is a water-soluble substance. What does this mean? Name two other water soluble substances.

16 a Below are the instructions for an experiment to obtain and then weigh the salt in sea water. It is set out like a recipe with 10 steps, but someone has jumbled them up. Arrange the steps in the correct sequence.

- When all the water has evaporated, let the basin cool.
- Subtract the mass of the empty evaporating basin to find the mass of salt.
- Collect a sample of sea water.
- Turn off the Bunsen burner and let the remaining water evaporate.
- Measure out 100 mL of filtered sea water in a measuring cylinder.
- Scrape and wipe out the salt and weigh the evaporating basin again.
- Filter the water to remove undissolved material.
- Heat gently over an evaporating basin to evaporate the water.
- Weigh the evaporating basin with the salt in it.
- Pour 100 mL of sea water into an accurately weighed evaporating basin.

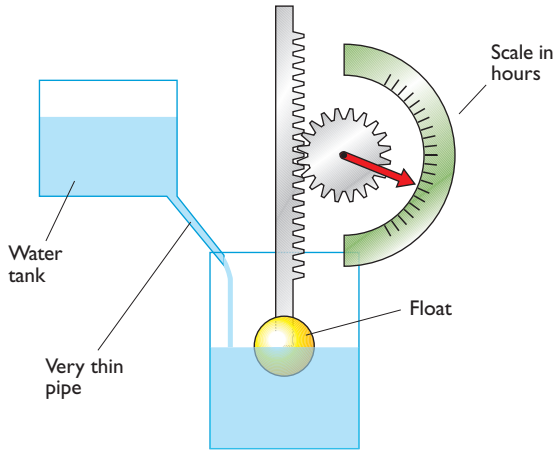
b Draw a diagram of the experiment to evaporate the water. Remember to include labels.

c In an experiment like this, a group of students found that the evaporating basin had a mass of 89.3 g after the salt had been wiped out of it, and it had a mass of 92.7 g with salt in it. How much salt did they crystallise?

d What is the concentration of salt in sea water, in grams per 100 mL?

Thinking questions

1 The diagram shows an ancient water clock.



How a water clock works

a Explain how the clock works.

b Does the hand on the clock move clockwise or anticlockwise as water drips into the beaker?

c If some dirt partly blocked the flow of water, would the clock run slower or faster? Explain.

d Would the clock run faster or slower if you used honey instead of water?

e This clock would not be suitable to use in a very cold area. Why?

2 Draw a flowchart showing the stages in sewage treatment.

3 When a car engine is started on a cold morning, you can often see condensation and water drops coming from the exhaust pipe.

When a car is started on a cold morning, water vapour condenses from the exhaust

Explain why this condensation appears. How is this process like distillation?

Word Check

Can you spell these words? Do you know what they mean? Write them into your Spelling and Vocabulary List.

condensation	fertiliser	reticulation
condense	freezing	scald
crystallisation	heaviness	sewage
density	hydrometer	solidification
disinfectant	hydrosphere	sublimation
distil	liquefy	sublime
distillate	liquid	vaporisation
distillation	meniscus	vaporise
evaporation	purification	vapour

Extra-hard words:

cryptosporidium	nausea
diarrhoea	reservoir

Research Questions

You will have to look in a dictionary, encyclopedia or CD-ROM to answer these questions.

1 What is meant by potable water?

2 What is the difference in meaning between these words?
- **a** scold and scald
- **b** sewage and sewerage.

3 Match these words with their meanings: avalanche, cloud, glacier, geyser, iceberg.
- **a** a large block of floating ice
- **b** a jet of hot water coming from the ground
- **c** a mid air collection of water droplets
- **d** a large amount of ice slowly moving down a mountain side
- **e** a large amount of ice crashing down a mountain side

4 The oceans contain 98% of the Earth's water.
- **a** How much water, in litres or cubic kilometres, are in the oceans?
- **b** How much salt is in one litre of salt water?
- **c** What is the average depth of the oceans?
- **d** How much water falls in a single thunderstorm?
- **e** How is hail formed? How big is the biggest hailstone?
- **f** When it is raining heavily, some people say 'It's raining cats and dogs'. Is there any truth in this saying? Can it rain frogs or fish?

5 There are many health problems concerned with the supply of drinking water and the treatment of used water, Research one of the following:
- **a** The Wallis Lake hepatitis scare in 1996.
- **b** Cryptosporidium in Sydney's drinking water.
- **c** The use of fluoride in drinking water for healthy teeth.
- **d** How sewage is treated in your area.
- **e** Eutrophication.
- **f** Blue-green algae (cyanobacteria) growth in lakes and rivers.

Concept map

Draw a concept map of the ideas in this chapter.

Water Crossword Clues

Across

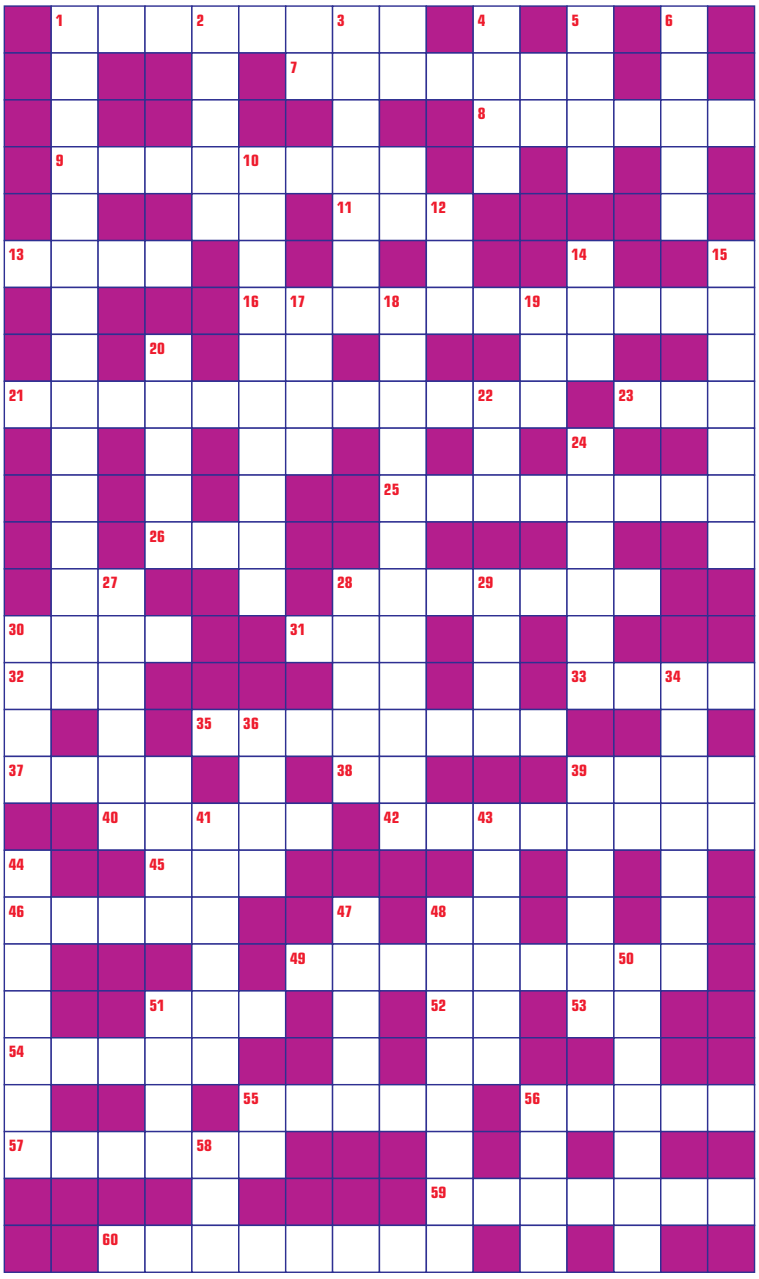
1 To change gas into a liquid
7 To change a solid into a gas without melting
8 This dissolves in a solvent to make a solution
9 To change from a liquid into a solid
11 When you ___ three and four you get seven
13 Small balls of ice made in thunderstorm clouds
16 Used to measure temperature
21 Evaporating and condensing a liquid
23 Used to hold tea, coffee or soup
25 This cobalt compound is used to test for water
26 Shortened boy's name, also used outside a door to wipe your feet on
28 River of ice which flows down mountains
30 What you do when you heat a liquid and it changes to a gas
31 A large body of salt water, smaller than an ocean
32 Initials of Australia's Natural Resources
33 The missing direction from North, South and West
35 A test for water using cobalt chloride or copper sulfate
37 Food made of boiled vegetables and meat, see 23 across
38 Initials of Southern Oscillation
39 Common name of the solute in sea water
40 A solute some people put in tea, coffee and milo

42 Opposite to positive
45 Small furry animal famous for living in drains and sewers
46 Carries water from mountains to the sea
49 Name given to the filtering and disinfecting of the water we drink
51 The drops of water seen on the ground and cars after a cold night
52 Initials of Physical Education
53 Initials of South Australia
54 What teachers and parents hope you do when you come to school
55 What this chapter and crossword is about
56 Where food and water enters your body
57 Three legged stand used with a gauze mat
59 Copper _____ is made of blue crystals
60 Cobalt _____ is used to test for water

Down

1 Process of obtaining crystals by evaporating water from a solution
2 Pipe or gully which carries waste water away
3 Blue crystals of copper _____ are used in testing for water
4 A cloud made of small drops of water which floats in the air near the ground
5 Change from a solid to a liquid
6 What this chapter and crossword are about
10 The purified liquid which is made in a distillation
12 Large container which holds water behind a wall
14 Drops of water which are found on the ground and cars after a cold night
15 A small drop of water
17 One divided by two
18 Name given to the system of pipes which carry water from the dam to our homes
19 Females are women, males are ____
20 Droplets of water made when water boils
22 A liquid which floats on top of water
24 Change when water turns into ice
27 High level clouds made of ice crystals
28 Disease-causing bacteria which are removed from drinking water
29 Brown coloured soft drink
30 Tea ____ act as a filter and were used as rockets in Chapter 1
34 Liquid which dissolves a solute to make a solution
36 Need to change a solid to liquid, liquid to gas, and to increase temperature
39 The three _____ of matter are solid, liquid and gas
41 Outdoor place where plants grow and people water with a hose or sprinkler
43 Concrete strip between the footpath and road which carries rain water to a drain
44 Mist and dew are made of these small drops of water
47 Solid water found on the ground and cars on a freezing morning
48 The change of a liquid into a gas
50 Made by nature, not by people or machines
51 A small amount of liquid water
56 When ice changes to water
58 Liquid which floats on water

WATER CROSSWORD



SOLUTIONS: PAGE 229