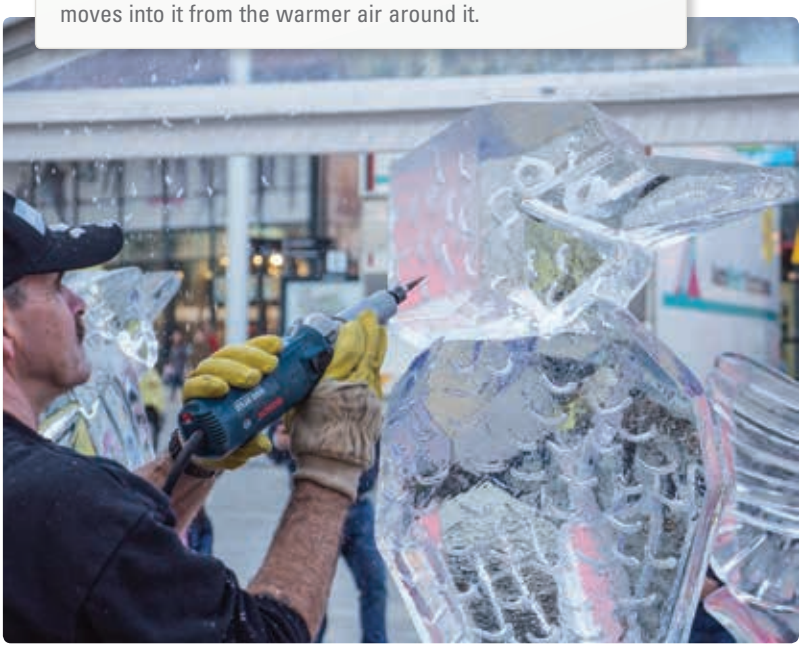
Changing states

Water is the only substance on Earth that exists naturally in three different states at normal temperatures. It is in the oceans, in the polar ice and in the air as water vapour. Water is constantly moving and changing states. You can observe water changing states in the kitchen. To change the state of any substance, including water, it must be heated or cooled, or the pressure changed.



Unfortunately, the ice sculpture in the photograph won't last for very long. Even as the sculptor works, it is melting as heat moves into it from the warmer air around it.

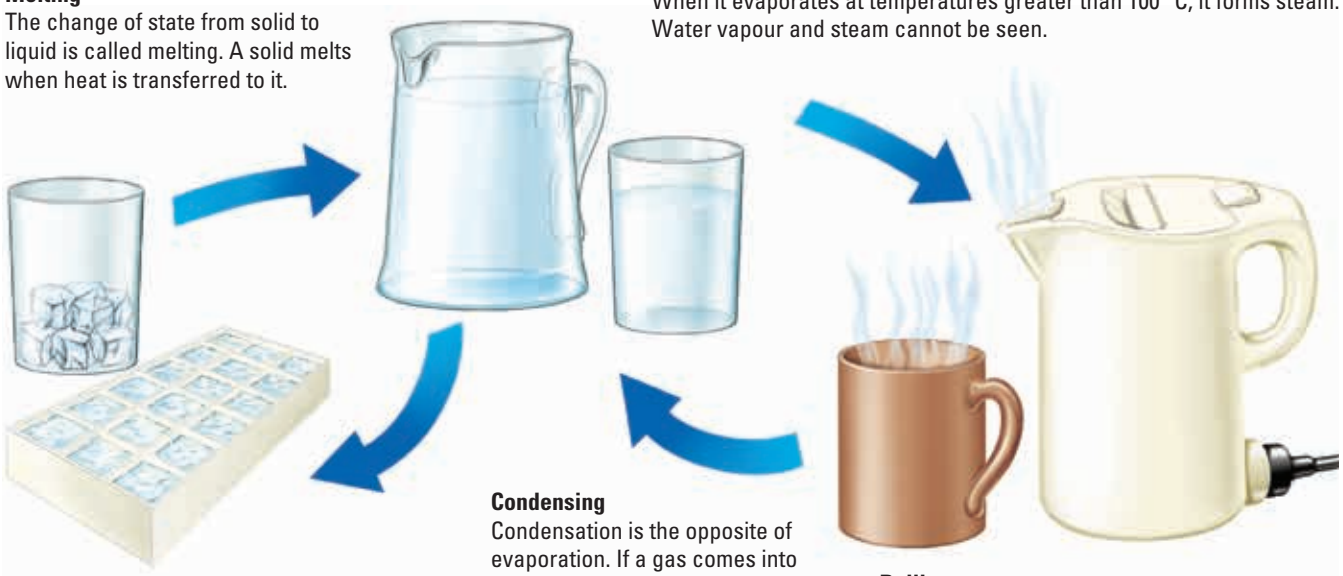
Melting point and boiling point

The state of matter of any substance depends on its temperature. The temperature at which a substance changes from a solid into a liquid (melts) is called its **melting point**. A liquid changes into a solid (freezes) at the same temperature. Water has a melting point of 0 °C, so to melt ice it has to be heated to a temperature of 0 °C. To freeze water it has to be cooled to a temperature of 0 °C.

The **boiling point** is the temperature at which a substance boils. At this temperature, the substance changes from liquid into gas (evaporates) quickly. At the same temperature, a gas changes into a liquid (condenses). The boiling point of water is 100 °C. The melting and boiling points of some common substances are shown in the table on the next page.

Melting
The change of state from solid to liquid is called melting. A solid melts when heat is transferred to it.

Evaporating
Evaporation occurs when a liquid changes to a gas. When water evaporates at temperatures less than 100 °C, it forms water vapour. When it evaporates at temperatures greater than 100 °C, it forms steam. Water vapour and steam cannot be seen.



Freezing
The change of state from a liquid to a solid is called freezing. A liquid turns into a solid when heat is transferred away from it.

Condensing
Condensation is the opposite of evaporation. If a gas comes into contact with a cold surface, it can turn into a liquid.

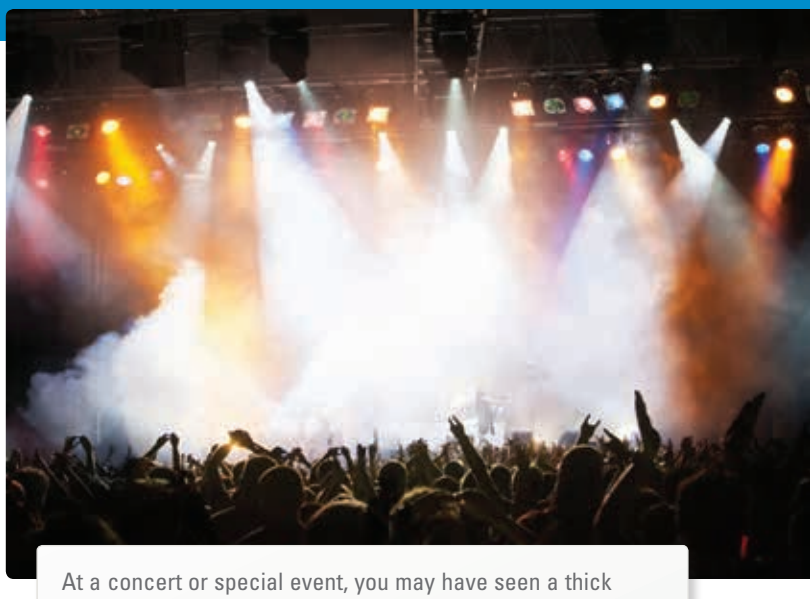
Boiling
During boiling, the change from liquid to gas (evaporation) happens quickly. The change is so fast that bubbles form in the liquid as the gas rises through it and escapes. During boiling, the entire substance is heated. A liquid remains at its boiling point until it has all turned into a gas.

HOW ABOUT THAT!

Melting and boiling points change with the height above sea level. This is because the air gets thinner as you move away from the Earth's surface. If you were climbing Mount Everest and made a cup of coffee near its peak, you would find that the water boiled at about 70 °C instead of 100 °C.

Melting and boiling points of some common substances at sea level

Substance	Melting point (°C)	Boiling point (°C)
Water	0	100
Table salt	804	1413
Iron	1535	2750
Aluminium	660	1800
Oxygen	–218	–183
Nitrogen	–210	–196

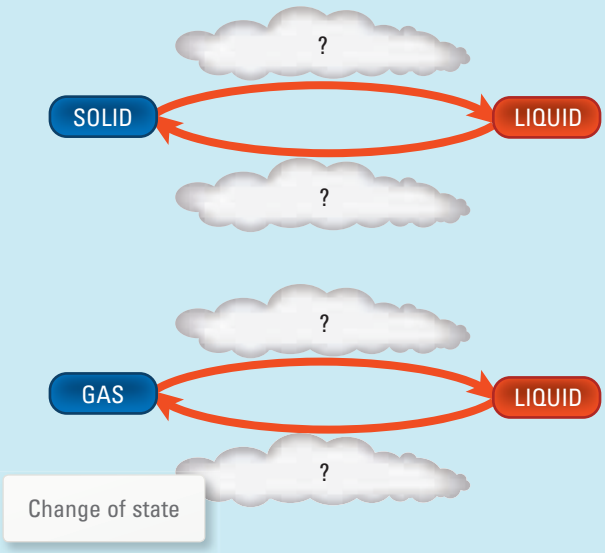


At a concert or special event, you may have seen a thick 'smoke' used for effect. This smoke is produced when solid carbon dioxide, called 'dry ice', changes state from a solid directly to a gas. This very unusual change of state is called **sublimation**. The 'smoke' is actually tiny droplets of water that condense from the air as the cold dry ice sublimes. Dry ice sublimes at a temperature of –78.5 °C. Iodine also sublimes. Diamonds sublime at a temperature of 3550 °C.

UNDERSTANDING AND INQUIRING

REMEMBER

1 (a) Copy and complete the diagram below, labelling the changes of state.
(b) Use a labelled arrow to add 'sublimation' to your diagram.



Change of state

2 What is the name given to the change of state from liquid water to steam? What happens to make this occur?

3 What happens to liquid water when it is cooled below 0 °C? Has heat moved into or out of the liquid?

4 When water evaporates it can change state from liquid to a gas in the form of either steam or water vapour. Explain the difference between steam and water vapour.

ANALYSE

Use the table above to answer these questions.

5 At what temperature would you expect table salt to melt? At what temperature would it freeze?

6 Would you expect aluminium to be found as a solid, liquid or gas at:
(a) 200 °C? (b) 680 °C? (c) 1900 °C?

7 Which substance — oxygen or nitrogen — would freeze first if the temperature were gradually lowered?

THINK

8 Explain the difference between evaporation and boiling.

9 Why is dry ice useful to produce a 'smoke' effect? What other uses are there for dry ice?

INVESTIGATE

10 Dry the outside of a very cold can of soft drink or carton of milk and allow it to stand on a table or bench for about ten minutes. (Don't forget to put it back in the fridge afterwards.)
(a) What change occurred on the outside of the can?
(b) Where did the water come from?
(c) What change of state has occurred?

eBookplus

work sheet 6.1 Changing the boiling point of water

The state of the weather

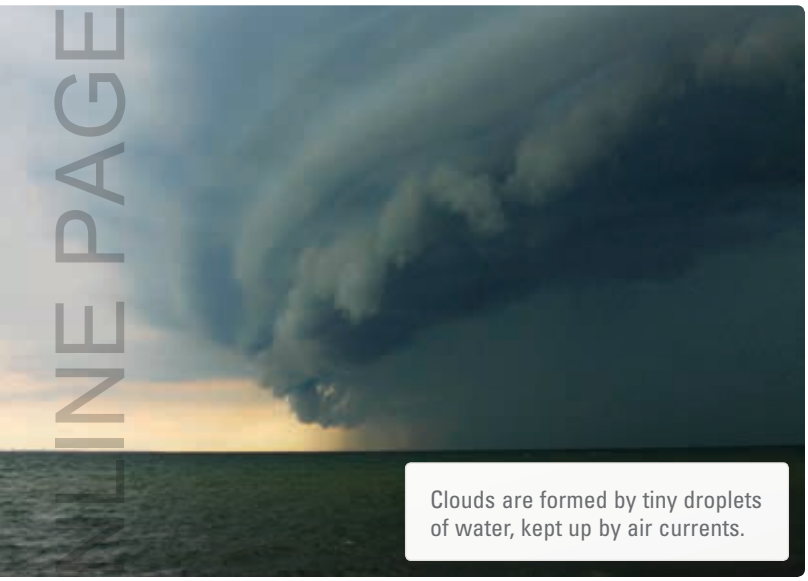
Rain, hail, snow and sleet are all types of **precipitation**. Precipitation is falling water, whether in solid or liquid form. All precipitation occurs because energy from the sun melts ice and causes liquid water to evaporate to become water vapour in the atmosphere. When the temperature in the atmosphere gets low enough, the water vapour condenses or freezes. That's when we get rain, hail, snow or sleet.

Water and the weather

The type of precipitation we get depends mostly on the temperature in the clouds and the air around them. It also depends on the amount of water vapour in the air and air pressure.

Rain

Rain forms when water vapour condenses in cold air, forming tiny droplets of water. These droplets are so small that they are kept up by moving air, forming clouds.



Clouds are formed by tiny droplets of water, kept up by air currents.

As the droplets join together they become too heavy to remain in the air. They fall to the ground as rain. When air currents are low, very tiny drops of rain may fall as a fine mist known as drizzle.

Hail

If drops of rain freeze, they may form hailstones. Air currents within clouds move raindrops from the bottom of the cloud upwards to the top of the cloud. The top of the cloud is much colder than the bottom and the rising raindrops freeze very quickly. The frozen raindrops fall back towards the bottom of the cloud.

In summer, warm rising air helps to keep the hailstones in the clouds for longer, forming even more layers than usual. These hailstones can reach masses of over one kilogram before they fall.

If the air currents are strong enough, the frozen raindrops rise again, adding a new layer of ice. They fall again, then rise again to form another layer of ice. This can happen over and over again, each time adding a new layer of ice. When the ice has built up many layers, it gets heavy enough to fall to the ground as a hailstone. Hailstones can be extremely large and cause extensive damage.

Snow

Snow consists of crystals of ice that have frozen slowly in clouds. Many different shapes and patterns can be found in snowflakes. The shape and size depend on how cold the cloud is, its height and the amount of water vapour it holds. Crystals of ice form when clouds have temperatures below –20 °C. The crystals join together and fall. As they fall, they become wet with moisture but then refreeze as snowflakes.

If the air between the cloud and the ground is colder than 0 °C, the snowflakes fall as very powdery, dry snow. If the air is warmer, the ice crystals melt and fall as rain or sleet.

Snowflakes form many different shapes and patterns but always have six 'sides'.

Sleet

Sleet is snow that is melting or raindrops that are not completely frozen. Sleet forms when the air between the clouds and the ground is warm enough to melt ice.

eBookplus eLesson

Understanding a weather forecast
Interpret weather maps for yourself and find out how isobars indicate air pressure.

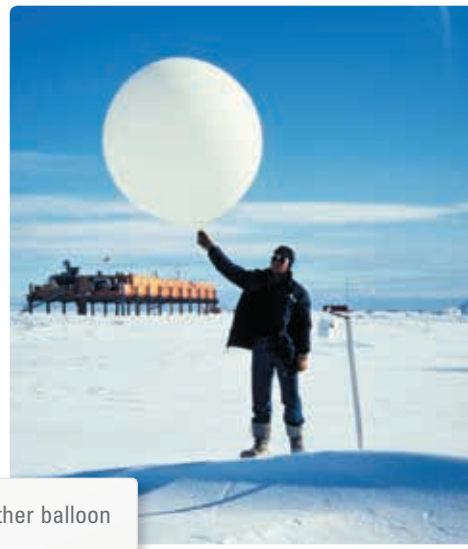
eles-0161

Predicting the weather

The scientists who predict, or forecast, the weather are **meteorologists**. Meteorology is the study of the atmosphere and includes the observation, explanation and prediction of weather and climate. Numerous observations of temperature, precipitation, wind speed, air pressure, humidity and more are needed to make weather forecasts. Humidity is a measure of the amount of water vapour in the air.

Before the first weather balloon was launched in 1882, observations with instruments such as thermometers, barometers and rain gauges could be made only on land or ships. Not long after the invention of the first 'flying machine' in 1903, weather instruments were attached to the wings of planes, allowing them to be taken higher in the atmosphere.

As new technology becomes available, the number and quality of observations improve. Improved weather balloons, together with radar, satellite images and computer modelling, allow meteorologists to make predictions further ahead and more accurately than ever before.



A meteorologist releases a weather balloon in Antarctica.

UNDERSTANDING AND INQUIRING

REMEMBER

1 What are clouds made of?
2 Using words or a labelled diagram, explain how hailstones are formed.
3 How can hailstones get as large as the one in the photograph on the previous page?
4 Explain the difference between snow and sleet.
5 What is meteorology concerned with?
6 What is humidity a measure of?

THINK

7 Suggest why extra-large hailstones are more common in summer than winter.
8 Ski resort operators suffer a shortage of snow in some years. What conditions would they look for to predict coming snowfalls?

INVESTIGATE

9 Make a list of leisure activities that rely on predictions about the weather.
10 In which occupations do each of the following types of weather prevent activity?
(a) Extreme heat
(b) Heavy rain
(c) Thunderstorms
11 Record the predictions of the maximum temperature of your nearest capital city made in a 7-day forecast. For each day of the 7-day period, also record the maximum temperature predicted on the day before.

These forecasts can be found online on the Bureau of Meteorology website (www.bom.gov.au), on the TV news or in daily newspapers.

Then record the actual maximum temperature for each day as reported on the evening news or www.bom.gov.au. Use a table like the one below to record your data.

Daily maximum temperatures (°C)

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Prediction in 7-day forecast							
Forecast the day before							
Actual maximum temperature							

(a) How does the accuracy of the 7-day forecast compare with the accuracy of the previous day's forecast?
(b) State your opinion about the accuracy of the forecast made on the day before.
(c) Apart from temperature, what other aspects of the weather forecast are reported in newspapers and on the TV news?

12 Find out what relative humidity is and with which instrument it is measured.
13 Research and report on what a hydrologist does.
14 Find out the difference between weather and climate.