Part 3 Particle model of matter

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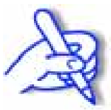
Contents – Part 3

Lesson 11 – Solids, liquids and gases

In this lesson you will consider solids, liquids and gases from a scientific perspective.

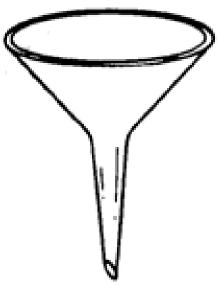
Looking at ice

Here is some equipment from the basic kit. Which piece of equipment do you think would be best to hold ice so that you can observe it?

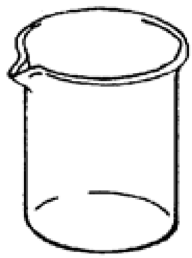


Activity: Looking at ice

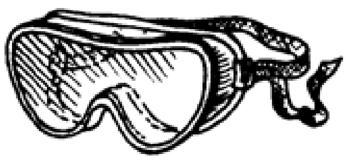
Tick the object below that you would choose.

❐ 

Filter funnel

❐ 

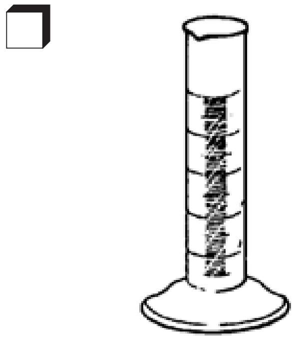
Beaker

❐ 

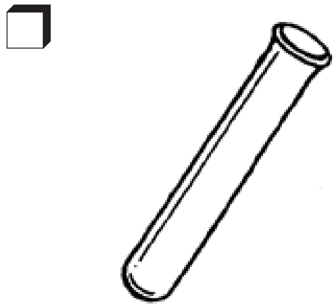
Safety goggles

❐ 

clock glass

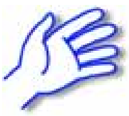


measuring cylinder



test tube

Did you choose the beaker? Now you can perform an activity using ice and the beaker.



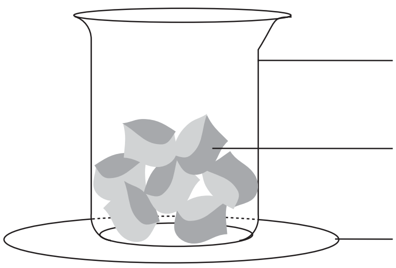
In this activity you are going to need to observe carefully and record what you see. Much of science is about observing, recording then interpreting.

You will need:

- a beaker (or a glass or a shiny metal tin)
- a piece of filter paper – these are circles (or a tissue or piece of paper towelling)
- about 6 ice cubes.

What to do:

Set up your equipment so that it looks like this.



Activity: Observing ice

Complete the sentences below to describe the equipment set up shown in the previous figure.

The missing words are in, on and under.

1 The beaker is ____________________ the filter paper.

2 The ice is ________________________ the beaker.

3 The filter paper is ________________ the beaker.

Leave the experiment to sit for a few minutes.

While you are waiting think about safety with respect to this experiment.

Do you think you should be wearing safety goggles to do this experiment?

Use the questions below to decide on an answer. Tick either yes or no for each question.

	Yes	No
Could anything splash during the experiment?	☐	☐
Could anything explode during the experiment?	☐	☐
Could any poisonous fumes be made during the experiment?	☐	☐

If you answered yes to any of the questions then you should wear your safety goggles. Even if you answered no, you could still wear them.

It is a good idea to wear your safety goggles during an experiment. You never really know what will happen.

Your experiment should be ready now.

What are three changes that you observe?

____

____

____

If you had trouble making three observations, leave the equipment and go on with the lesson. It will continue to change and you may see the changes more easily after more time.

There are some things that you may have observed:

- Some ice melted

  Ice is frozen water. It is a solid. In science, solid means a substance that has its own shape and is difficult to squash, or compress.

  What are three other solids around you?

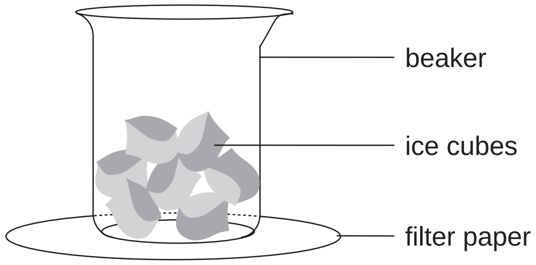
  ____

  Did you find it easy to think of examples?

  Almost everything around you is a solid. Your pencil is a solid. It always stays the same shape – like a pencil. What happens if you squeeze it? Nothing! It stays the same shape. It cannot be compressed.

- A solid has its own shape and is difficult to compress.

  What about the water in your beaker. What shape is it? Draw in and label liquid water in the diagram to show how it fills up space between the ice cubes and the bottom of the beaker.



  Water is a liquid. In science, liquid means a substance that does not have its own shape and is difficult to compress.

- The filter paper under the beaker became wet

  Where does this liquid come from? Make an inference.

  ____

  ____

  The liquid is water from the air. (The water is outside of the beaker so it could not come from the ice.)

- The outside of the beaker became moist.

  The moisture on the outside of the beaker is water that has come from water vapour in the air. You may even be able to see droplets of water on the outside of the beaker.

Make an inference about what made the water vapour change into liquid water.

Did you notice that the outside of the beaker is only moist near the ice?

Water vapour turns from a gas into a liquid when it cools.

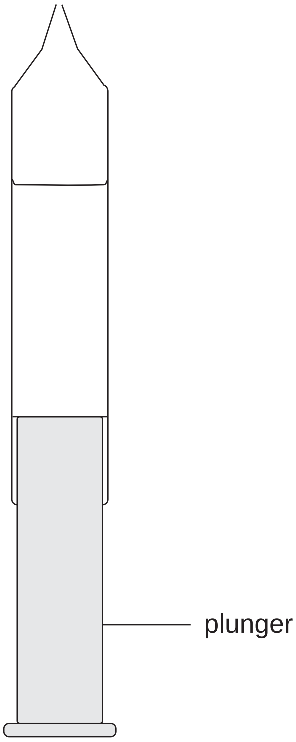
Activity: Investigating a liquid with a syringe

Some of the properties of a liquid can be studied using a syringe and water.

1 Here is a diagram of a syringe.

   a shade the liquid inside the syringe

   b What will happen if you push up on the plunger? Draw your answer onto the diagram.



2 Repeat the experiment but this time use a finger to block the hole in the end of the syringe. What happens?

Check your response by going to the suggested answers section.

Did you find that a liquid does not have its own shape and is difficult to compress? You should have.

Now you have investigated solids and liquid properties it is time for you to investigate gas properties.

Look around. Can you see any water in the air? Water in the air is called water vapour. Water vapour is a gas.

In science, gas means a substance that does not have its own shape and can be compressed.

To investigate gas properties you will need a balloon. Blow up the balloon so that it is about as big as your fist. Knot the balloon.

Activity: Investigating gas in a balloon

Use your balloon to investigate the behaviour of a gas.

1 Can you change the shape of the balloon? When you change the balloon’s shape you are changing the shape of the gas inside it.

   ____

   It is easy to change the shape of a gas because the gas does not have a shape of its own.

2 Can you squash the balloon and make it smaller?

   ____

   When you squash the balloon, you are compressing the gas inside it. It is easy to compress a gas.

   A gas does not have its own shape and is easy to compress.

Scientists divide all things into solids, liquids and gases. Even if something is in between a solid and a liquid, like toothpaste, scientists still decide to call it either a solid or a liquid.

Scientists call solids, liquids and gases the *three states of matter*.

You can learn a lot from a simple investigation, can’t you? Check your understanding and learning by completing this summary.

Activity: Summary

Complete the sentences below using these words. Each word is used once only.

compress	cooler	gas	ice
liquid	melts	solid	states
vapour	water		

1 The three ____________________ of matter are solid, liquid and gas.

2 It is easy to compress a ____________________ .

3 A ____________________ has its own shape.

4 A ____________________ does not have its own shape and it is difficult to squash, or ______________ .

5 Water vapour changes into liquid water when it gets ____________ .

6 Liquid water forms a solid called ________________ when it cools.

7 Ice ____________________ to liquid water when it gets warmer.

8 Water turns to _____________ _____________ when it is heated.

Check your response by going to the suggested answers section.

Go to the exercises section and complete the Exercise 3.1: Working safely with chemicals.

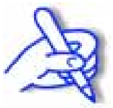
What did you achieve?

Tick what you can do.

- ❒ observe differences in the properties of solids, liquids and gases
- ❒ make inferences to explain observations
- ❒ plan and demonstrate safe work practices.

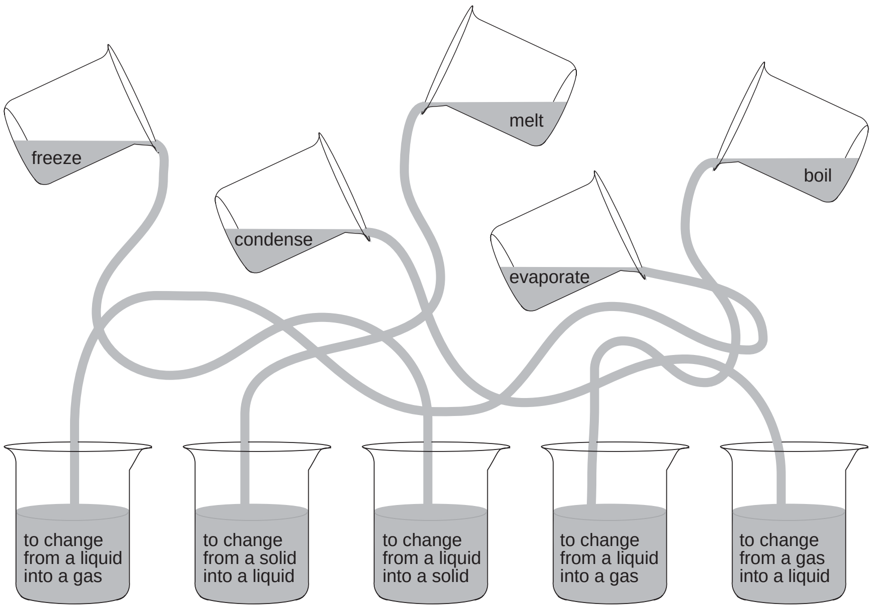
Lesson 12 – Changes of state

Changes from one state to another such as from a solid to a liquid or gas to liquid are called **changes of state**. In the beakers below are words that scientists use to name changes of state.



Activity: Changes of state

1 Trace from each word to its meaning, then use the meanings to complete the sentences below the puzzle.



a Freeze means to change state from ______________________
into ____________________ .

b Condense means to change state from ____________________
into ____________________ .

c Melt means to change state from ________________________
into ____________________ .

d Evaporate means to change state from ___________________
into ____________________ .

e Boil means to change from ____________________________
into ____________________ .

2 There are different forms of the scientific words about changes of state. Complete the table below.

Word	Present tense	Past tense	Name of process
freeze	freezes		freezing
condense			condensation
melt		melted	
evaporate			
boil	boils		

3 Now use words from the table to complete these sentences.

- Water is usually a liquid. It can ________________ into a solid called ice. Then _________________________ can change ice back into a liquid.
- Water can also ________________________________ forming a gas called water vapour.
- When water __________ , this change to a gas happens quickly.
- But as the gas cools again, it ________________ back to water.

Check your response by going to the suggested answers section.

Heat and change of state

The main cause of change of state is movement of heat.

If heat moves out of a substance there is a heat loss. Its temperature decreases.

If heat moves into a substance there is a heat gain. Its temperature increases.

Activity: Heat and change of state

Verb and statement directing students to complete/perform …

1 On the arrows put + heat if there is a heat gain, – heat if there is a heat loss.

solid ⇌ liquid ⇌ gas

2 On the arrows put temperature increase or temperature decrease.

solid ⇌ liquid ⇌ gas

3 On the arrows place the following words in the appropriate place.

- boiling or evaporation
- condensation
- freezing
- melting

solid ⇌ liquid ⇌ gas

Check your response by going to the suggested answers section.

How did you go? Get everything correct? If you made a mistake do you understand why you were wrong?

Temperature and heat

Temperature and heat are related but they are two different ideas.

Temperature measures how hot something is. Temperature helps you compare how hot something is compared with something else. Weather records of temperature in °C help us compare temperatures of different locations.

Heat is a form of energy that can be used to do work. Steam engines and engines that use petrol, diesel or gas as a fuel all get hot when they are working. Engines use heat energy to do work.

Heat energy always flows from a place of higher temperature to a place of lower temperature. If your skin is hot and you come in contact with ice you feel heat move out of your skin to the ice. If you touch a dog you will notice that its body temperature is slightly warmer than your body temperature. Some desert Aborigines used dingoes like hot water bottles on cold winter nights.

It is much more difficult to measure the amount of heat energy in an object than its temperature. The amount of heat energy depends on the mass of the object and the type of material it is made up of.

What is heat?

Scientists haven't always understood heat. In the 1700s most scientists thought heat was an invisible fluid that flowed between substances.

In 1798 Count Rumford (an American born man named Benjamin Thompson) was supervising the boring of cannons. He noticed that when the boring tool was blunt a huge amount of heat was released into the cooling water. However when the boring tool was sharp less heat was released to produce the same sized cannon. He also noticed the blunt tool produced more friction and vibration. Count Rumford thought heat must be a vibration set up and intensified by friction.

Count Rumford and a boring cannon task

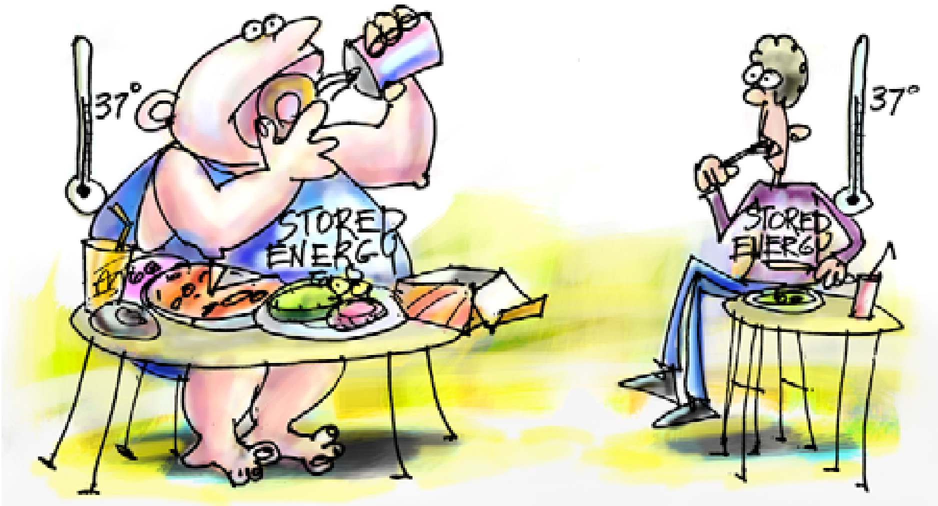
In 1799 the Englishman Humphry Davy investigated what happened when two blocks of ice (at temperatures below the melting point) were rubbed together. He found that friction between the ice blocks caused melting even though the temperature was below the melting point for ice of 0°C.

Friction melts ice

Scientists started to think of heat as due to vibration rather than a fluid. Flow of heat involved movement of vibration rather than a fluid from one substance to another. This idea was accepted by the mid 1800s.
Heat energy increases vibration and movement.

Energy and food

Energy is measure in **Joules** (symbol J). If you look at the labels on packaged food there is often information about the energy content per 100g of the food. The energy content of food is usually measured in **kiloJoules** (kJ) per 100g of food. The higher the energy content of foods that you eat the more energy your body is supplied with. If the total energy content of what you eat is greater than the energy your body needs you can get fatter.



Different energy intakes and different stored energies, same body temperature

Food	Typical Energy contents (kJ per 100g)
dried fruit	1400
biscuits	1800
chocolate	2200

Go to the exercises section and complete the Exercise 3.2: Energy content of foods.

What did you achieve?

Tick what you can do.

☐ describe evaporation, condensation, boiling, melting and freezing

☐ distinguish between temperature and heat

☐ identify how scientific knowledge has changed people's understanding of heat energy.

Lesson 13 – Particle model

What do you think is happening when a substance changes state?

Scientists looked for an explanation that would help them picture what was happening. You can call this a **model**.

In this lesson, you'll perform an activity that is a model for the states of matter.

For this activity, you will need:

- a beaker (or a strong glass or strong transparent plastic container such as a jar)
- a soft rag
- plastic wrap
- the freezer in a refrigerator
- some round things. Frozen peas are ideal but you could use small balls of plasticine or blue–tac™ or lollies such as Jaffas™, Koolmints™, Koolfruits™ or Jilamints™. You will have to throw away the peas or lollies after the experiment as they will be unfit to eat. Check with your supervisor that this is all right.

What if…

Scientists observed that some substances, such as water, could be changed from solids into liquids then into gases and back again. Heating and cooling these substances changed their state but nothing else. These changes were called **physical changes**.

Scientists wondered, what if you think of the substance as made up of very small balls? What if the balls don't change when the substance changes state? Only the arrangement of the balls changes.

In other words, the scientists created a model – a way to help them picture and explain what was happening when things change state.

This model is made up of inferences each explaining observations.

A model for the states of matter

The procedure below assumes you are using frozen peas and a beaker. If you are using other materials, adjust the procedure to fit your materials.

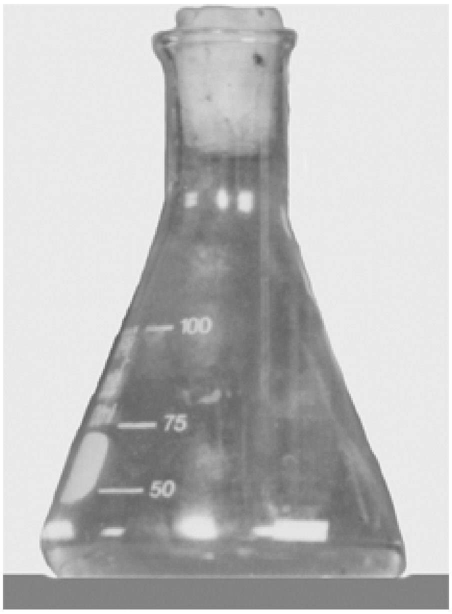
Each pea in this experiment represents the smallest piece of a substance. You could think of each pea as a particle of water.

What to do:

1 Crunch the packet of frozen peas before you open it so that you break up any clumps. But don't squeeze so hard that you burst the bag!

2 Pour frozen peas into the beaker to a depth of about 3 cm. Wrap the beaker in plastic wrap, making sure that you can still see into the side of the beaker.

3 Here is a photograph of a flask of gas. Notice that there is a cork in the top of the flask to stop the coloured gas from escaping.



What could you do with your beaker of peas to make it resemble the gas in the flask?

Did you think of shaking the beaker of peas?

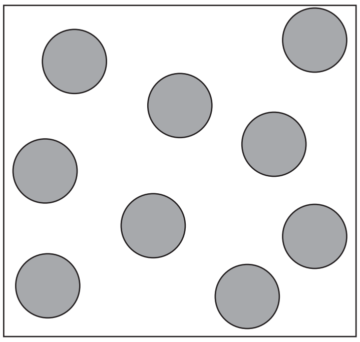
If you are using hard balls such as marbles or lollies, don't! You might break the glass. If using peas, try it.

Did you notice that peas fly about everywhere inside the beaker? Everywhere in the beaker has some peas but there is lots of space between them.

Can you use this model to explain what a gas is like? A gas does not have its own shape and it is easy to compress.

Activity: Modelling a gas

Here is a ‘snapshot’ of the peas while you were shaking the beaker.



1 Would the peas still go everywhere inside a container with a different shape if you shook it?

____

____

2 Could you compress (squash) the peas closer together?

____

____

When you shake the container, the pea ‘gas’ will be whatever shape the container is. And the pea ‘gas’ can be compressed because there is lots of space between the peas.

If you think of gas as a lot of balls (particles), you can explain some observations. Thinking of the gas as moving particles is using the model.

Now try this.

1 Slowly turn the beaker of peas over and over. What happens? Did you notice that the peas roll over each other?

2 Stop the beaker in any position. What shape do the peas make? It's whatever shape is at the bottom when you stop the beaker. This is like a liquid because a liquid does not have its own shape. Instead it takes the shape of the bottom of the container.

3 Is there much space between the peas in the beaker? The peas are close together.

Is your peas in a beaker a good model for a liquid?

Activity: Modelling a liquid

Use the particle model to explain why a liquid cannot be compressed.

____

____

Check your response by going to the suggested answers section.

Here are the steps you have used so far in trying to explain the states of matter. There are only four steps but they are jumbled.

Activity: Checking the steps

Number the steps from 1 to 4 in the order that you have done them.

☐ Look for a pattern in the observations.

☐ Observe the properties of solids, liquids and gases.

☐ Test if the model can explain other observations.

☐ Make a model that explains the observations.

If you are thinking scientifically, you've got the order correct!

Check your response by going to the suggested answers section.

The particle model

The particle model was made up to explain changes of state – how one substance could change from a solid to a liquid to a gas and back again.

You've tested the model by seeing if it can explain the properties (features) of gases and liquids. Yes, it did explain why gases and liquids do not have their own shape and why gases can be compressed but liquids can't.

When an idea or a model has been tested and can explain different types of observations, it is often called a **hypothesis**.

A hypothesis is an explanation of observations that usually links several inferences. A hypothesis can be used to make predictions that can be tested.

You can call your particle model (beaker of peas) a hypothesis. Why?

____

____

You can call the model of the beaker a hypothesis because it can be used to make predictions that can be tested.

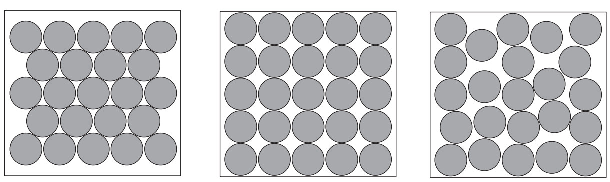
Can your peas in a container model a solid state?

Activity: Modelling a solid

Gently tap the base of the beaker onto the rag so that the peas inside it pack together.

Think about safety! The beaker is made of glass. Be careful not to knock it too hard or it may break and broken glass can be dangerous. Always treat glassware carefully.

1 Look through the side of the beaker at the pattern made by the peas. Which pattern below is most like your peas? Circle it.



A B C

If yours look like C then you haven't broken up the lumps or you haven't tapped the beaker for long enough.

Is there any space between the peas to be able to compress them (without squashing the peas themselves)? The peas should be very close together. They cannot be compressed.

2 Your peas have probably begun to melt. (That's good!)

Keep the beaker steady so that the peas stay in the pattern and put the beaker into the freezer. (If you are using balls of plasticine, press them gently together. If you are using marbles or round lollies, use blue tack to stick them together into a clump.)

If you check your model after about 20 minutes, you'll find that the peas have stuck together into a solid. You can shake it out of the beaker and hold it. It has its own shape because all the particles (peas) are held in position in the pattern.

Cleaning up

Put your peas onto the garden or in the compost heap. Lollies should be discarded in the rubbish bin.

Think about safety!

Why wouldn't you eat them?

The peas or lollies have been in your science equipment.

They may have some poisonous chemical on them.

Wash your beaker under a tap outside. Leave it somewhere safe to dry or dry it with your rag. Wipe your workspace too. Always leave your workspace clean and tidy.

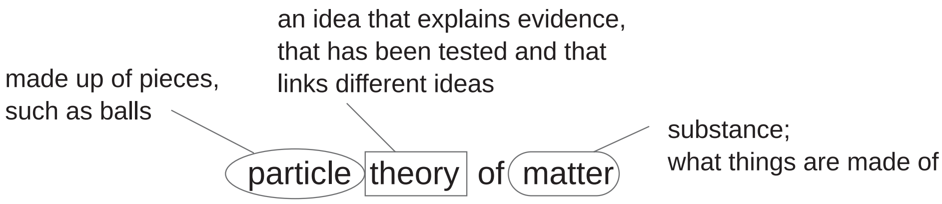
The particle theory of matter

A particle model, similar to your pea model, has been tested and used for many years. Scientists have found that it is useful for explaining many different observations and inferences.

When a hypothesis based on a small number of assumptions explains a lot of experimental evidence it can be called a **theory**. Assumptions or ideas you have used in your model include:

- matter is made up of small particles
- the particles are able to move
- the particles have forces of attraction between them.

The model you've been using is a theory. It is called the particle theory of matter.



The particle theory of matter states that all substances are made of particles.

These particles move and interact with each other.

Go to the exercises section and complete the Exercise 3.3: Explaining the states of matter.

What did you achieve?

Tick what you can do.

- ❐ use the particle theory of matter to explain why matter exists in three states – solid, liquid and gas
- ❐ distinguish between temperature and heat
- ❐ model the particles in a solid, a liquid and a gas.

Lesson 14 – Physical changes

Add enough heat to liquid water and it forms a gas.

At temperatures below the boiling point of water (normally 100°C) the water evaporates to form water vapour.

At 100°C the water boils to form steam. Both water vapour and steam are gaseous forms of water.

Activity: Investigating gaseous forms of water

What you will need:

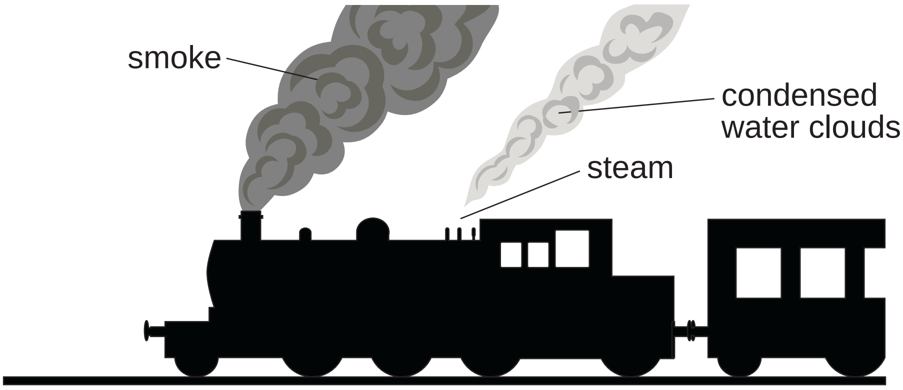
- a source of boiling water such as a kettle (heated or electric)
- a can or bottle of cold drink from a refrigerator
- a small towel, dry rag or paper towel
- a source of cold, gently running water

Be careful with the boiling water and the steam coming from the kettle. If you are burnt, immediately cool any burns under cold, gently running water for at least ten minutes.

What you will do:

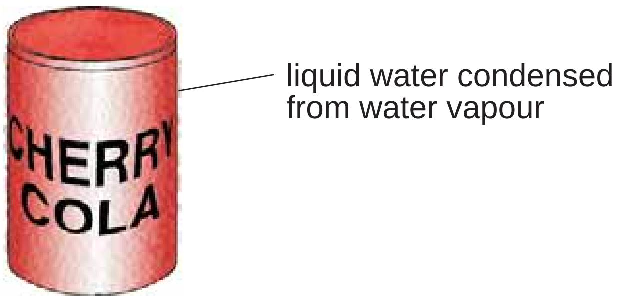
1. Take the container of cold drink from the refrigerator and wipe its outside to make sure it is dry.
2. Place the container on a horizontal surface well away from the kettle and leave it for at least ten minutes.
3. Set the kettle up so that the water in it boils.
4. Look at the steam where it just comes out from the kettle. Is the actual hot steam, at a temperature close to 100°C, visible or not? When you have made a decision turn the kettle off.
5. Now go over to the container of cold drink and run a finger up its side. Is it wet or dry to touch? If you're not sure leave it for a further ten minutes then come back and see if it is wet or dry.

Hopefully you observed that the steam, where it just comes out of the kettle, was not visible. The hot, fast moving water particles are too small to be seen. What you saw further out from the kettle were little clouds of condensed liquid water. When steam cools in the air it forms little droplets of water that make up the clouds. These little droplets have surfaces that reflect a lot of light and so look white. What people call steam coming from a steam locomotive is not really steam. It is the clouds of condensed water droplets that have formed when the steam cooled in air.



Steam locomotive

Where did the liquid come from that appeared on the outside of the drink container? It didn't come through the walls of the container, it came from water vapour in the air. Air is typically 1-3% water vapour. When the water vapour hits a cold surface it condenses to liquid water. Particles of water that were moving at high speed in the air come close together so that they touch and form liquid water.



Condensation forming on a cold container

Activity: Investigating solid water

What you need:

- two ice cubes (plain ice is fine)
- a small towel or dry rag

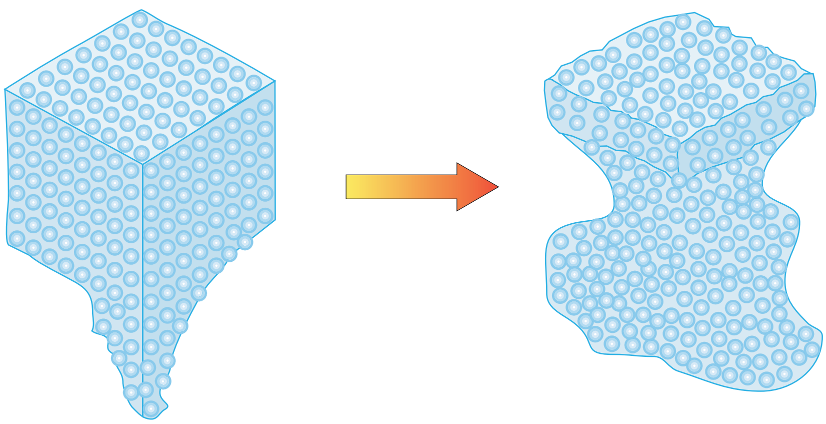
What you will do:

1. Hold the two ice cubes in the towel so that their flattest surfaces are exposed to the air. Carefully examine the surfaces.
2. Press the two flat surfaces together for at least ten seconds. Try to pull them apart.
3. If the two ice cubes pull apart, wait half a minute then repeat step 2. If they don't join, try waiting a minute before repeating step 2.

Hopefully you observed that the ice cube surfaces changed in appearance. Heat from the warmer air starts to melt the solid surface. When you hold the two moist surfaces together the moisture often freezes by losing heat to the cold ice cube. This frozen layer can join the two ice cubes together. You may have noticed that when you put small ice cubes into a glass of drink that sometimes the ice cubes freeze together to form a larger piece of ice.

In this activity you can observe the melting of ice and the freezing of liquid water to solid ice. Which change involved loss of heat and which involved gain of heat?

Melting of ice involves gain of heat by the ice to form liquid.



Freezing of liquid water to ice involves some loss of heat.

Physical changes and heat

A **physical change** is a change that does not make a new substance. Any change of state is an example of a physical change.

A change of state is where a solid changes into a liquid or a liquid becomes a gas or a liquid becomes a solid or…

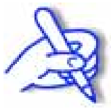
…a gas becomes a liquid.' would be a suitable end to this sentence.

So the changes of state evaporation, boiling, condensation, melting and freezing are all physical changes.

When a substance changes state the particles do not change. The particles are the same size and shape whether they are in the solid, liquid or gas state. What changes is the positioning of the particles and how much they move.

Solid	Particles close together in regular positions.
Liquid	Particles close together moving freely over one another.
Gas	Particles widely separated and moving at high speed.

The more heat energy a substance has the more its particles move.



Activity: Heat and changes of state

Complete these questions to revise your understanding of heat and changes of state.

1 Which state of matter contains the most heat energy? ____________

2 Which state of matter contains the least heat energy? ____________

3 Which of the changes of state (evaporation, boiling, condensation, melting and freezing) requires addition of heat energy?

____

4 Which of the changes of state (evaporation, boiling, condensation, melting and freezing) requires removal of heat energy?

____

Check your response by going to the suggested answers section.

Changes of state in water are essential for the well-being of the Earth.

The water cycle

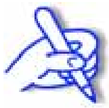
Water is the most amazing substance on Earth!!!

It is the only substance found naturally in solid, liquid and gas state. All living things contain water. Moving water shapes the surface of the Earth. Water affects the climate.

Just look at the weather forecast – it may contain information about the temperature of sea water, the percentage of water vapour in the air (**humidity**) and the likelihood of liquid water (rain) or solid water (snow, hail) falling from the atmosphere. If you look around the Earth you can see liquid water (blue in large amounts), solid water (as snow or ice) but not the gaseous water (water vapour in the air).

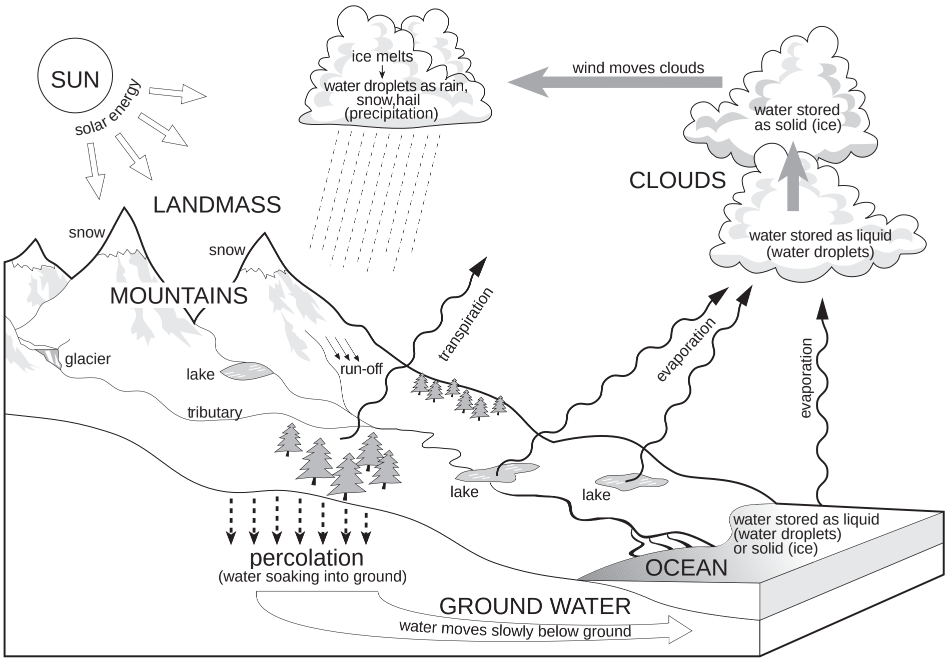
Look at clouds. What you see can be made up of small droplets of water (white roundish clouds), large droplets of water (dark rain clouds) or ice crystals (high altitude clouds).

The movement of water on and around the Earth and its changes of state are best shown in a diagram called the water cycle.



Activity: Water cycle diagram

On the diagram below write S (solid), L (liquid) and G (gas) to show the states of water in various locations.



Check your response by going to the suggested answers section.

In this lesson you were working scientifically by making observations, using models and finding patterns.

Go to the exercises section and complete the Exercise 3.4: Examples of working scientifically.

What did you achieve?

Tick what you can do.

❐ describe physical changes of water caused by heat loss or heat gain?

Lesson 15 – Chemical changes

Making a new substance is called a **chemical change**. Chemical changes often require heat to start or release heat as they proceed.

In this lesson's investigations, you will have to decide if you are changing the state of something (a physical change), or making something new (a chemical change).

Activity: Heating some water

For this activity, you will need:

- a beaker (or a disposable aluminium pie plate)
- a spirit burner (or a candle and candle holder) or a Bunsen burner
- a sand base to go under your spirit burner
- all the equipment to fill your spirit burner if you stored it empty
- matches
- a rag
- safety goggles

Do you think heating some water using this equipment will make any new substances?

What do you predict will happen to water when you heat it?

❒ There will be no change.

❒ The water will change state by evaporating.

❒ The water will change into a new substance.

Hope you said that the water would evaporate, making water vapour.

Since you know what will happen to the water, look at something else during this experiment!

Read each instruction step through before going ahead with the instruction.

What to do:

1 Put about 1 cm depth of water into your beaker. Make sure that underneath your beaker is clean and dry.

2 Light your spirit burner/candle and hold the beaker over the flame – it won't get very hot because you only need to hold it there for about 5 seconds. Put the bottom of the beaker as close to the flame as you can (without putting the flame out) and try to hold it still.

3 Now look at the bottom of the beaker. What are two things you observe? (If you didn't notice two things, try the experiment again.) When you can make two observations, put out your burner and write your answers below.

   - ____
     ____
   - ____
     ____

Different people can make different observations. It depends on what you are looking for. The kind of observation you make can depend on what you understand and what you expect.

Is the change a change of state or are you making a new substance? In other words is it a physical change or a chemical change?

Here are two observations.

- There is a black area on the bottom of the beaker where it was heated.
- There is a 'foggy' area around the black area.

So there are two substances on the bottom of the beaker that were not there before. What are they and where have they come from?

The base of your beaker should be cool enough to touch. Touch the foggy area. What do you think it is?

____

Yes, it is water.

Where could this water have come from? Could it have come from water vapour in the air? What do you need to do to change the state of water vapour in the air to liquid water?

To make a gas condense, you need to cool it.

But in this experiment you have been heating not cooling. So the water on the bottom of the beaker did not come from the air.

What inferences can you make about the black stuff on the beaker? What do you think it is?

It is often called soot. Another name for it is carbon.

Where do you think the carbon has come from?

Did you infer that it came from the spirit burner?

What about the water? Could that have come from the burner too?

Both carbon and water can be made when methylated spirit (or candle wax) burns in air. Burning is a change that produces new substances.

Tick the best statement about this experiment from the ones below.

☐ Burning is a physical change because liquid methylated spirit changes into solid carbon and a gas called water vapour.

☐ Burning is a chemical change because new substances are made.

☐ Burning is a chemical change because liquid methylated spirit changes into a solid and a gas.

Check your response by going to the suggested answers section.

Activity: Reviewing physical and chemical changes

Use these words to complete the sentences below.

chemical	evaporates	melting	physical
condenses	freezing	no	water vapour

1 In this lesson, I've learned about two kinds of changes.

A change of state is a physical change because there are ________

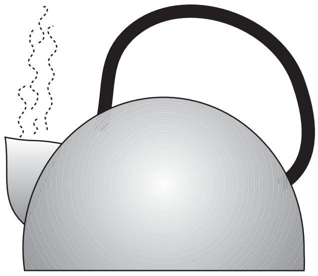
new substances made.

New substances are made in a ____________________ change.

Burning is an example.

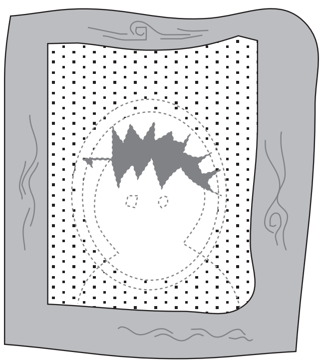
2 When water boils, it changes to steam

or ______________ .



When steam hits a cold mirror,

it _________________ into water.



When washing dries, water

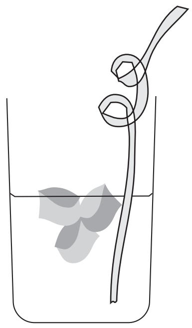
_______________ and becomes

water vapour.

__________________water makes ice

and __________________ ice makes

water.



These are all examples of ____________________ changes.

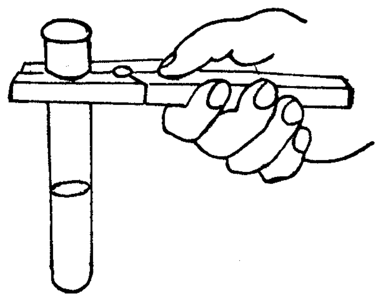
Check your response by going to the suggested answers section.

Activity: Heating some vinegar and …..

If you have not learnt how to heat a liquid safely in a test tube, read through the information below and do the safety check test before beginning this activity.

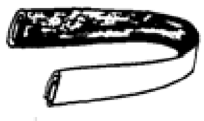
Heating liquid in a test tube

First put the liquid that you need to heat in the test tube. The test tube should never be more than about half full of liquid.

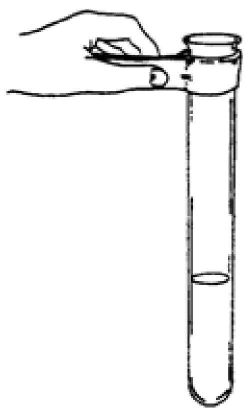


Hold the test tube in the test tube holder. The holder should be placed up near the opening of the test tube.

If you cannot use the test tube holder, a piece of folded paper makes a good substitute.

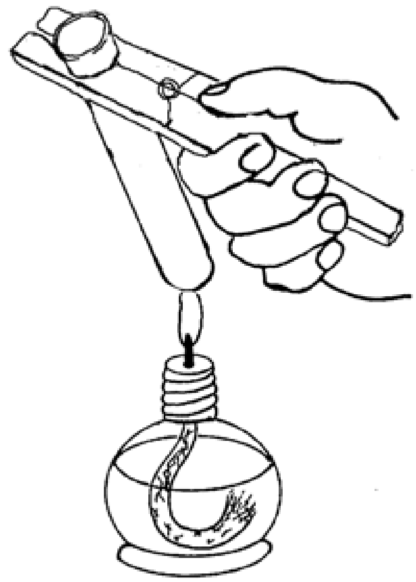


Fold the paper until it is about 2 or 3 centimetres wide. The diagram shows you how to use the folded paper as a holder.



When you heat the test tube, tilt the tube so that you do not set fire to the holder or the paper.

Move the test tube around in the flame so that all the parts are heated evenly. If you heat the test tube in one spot, the liquid can 'bump' and spurt out of the test tube.



When you are heating, make sure that you do not point the test tube at yourself or anyone else in the room.

Safety check test

One of the best things you can do before any experiment is perform a safety check.

Activity: Safety check test

Cross out one of the words or phrases in each bracket so that the correct word or phrase is left.

1 When heating liquids in a test tube, you should hold the test tube in (your fingers/a test tube holder).

2 The test tube should be no more than (half/three quarters) full.

3 When the test tube is heated it should be (tilted/upright).

4 The mouth of the test tube (should/should never) be pointed at anyone.

5 To heat the liquid evenly, you should (move the test tube around/ keep the test tube still).

6 You should wear your safety goggles when you heat a liquid in a test tube. Why?

7 Should you heat a liquid in a glass if you do not have a test tube? Explain.

Check your response by going to the suggested answers section.

Supervisor needed?

Experiments are not dangerous if they are done following the instructions and using common sense. It is important to always think about safety.

So before you begin any experiment, let your supervisor know what you are going to do. You should be able to describe the steps in the activity and explain what you will do to make sure that you (and others) will be safe.

Think particularly about the chemicals you may use and about how to act safely if you are using a spirit burner with methylated spirit. Make sure that you read and follow any safety instructions in your student booklet and on packages.

Your supervisor may want to watch you do the activity.

It is a good idea to collect all the things you need for your experiment before you begin.

Write directly into your booklet being careful not to spill liquids or chemicals on the pages.

And remember to think about safety. Always try to predict what might go wrong and think of a way to avoid danger.

Heating some vinegar and…

Do you have a basic kit?

Yes Start on this page.

No Go to the following page.

If you have a basic kit

You will need:

- 2 test tubes
- labelling pen or 2 labels
- a test tube rack (or a beaker and a glass)
- safety goggles
- vinegar
- carb soda (sodium bicarbonate). You should have your own pack for experiments. If you have to use the pack from the kitchen, put a tablespoonful into an old container. You cannot put the carb soda back into the kitchen pack after the experiment.
- 2 spatulas or plastic spoons
- matches
- a spirit burner
- a sand base to go under your spirit burner
- all the equipment to fill your spirit burner if you stored it empty.

What to do:

1 Label one test tube as 'cold' and the other as 'hot'. Pour about 2 cm depth of vinegar into each test tube.

2 Put on your safety goggles.

3 Light your spirit burner (remember to follow the steps to use it safely) and gently warm the vinegar in the test tube labelled ‘hot’. You do not need to boil the vinegar.

4 Put the test tube into the test tube rack or stand it in your beaker. Put out your burner.

5 Measure about 1/4 teaspoon of carb soda onto each spoon. You need to hold a spoon in each hand. Drop the carb soda into both test tubes at the same time and watch what happens.

If you do not have a basic kit

You will need:

- 2 cups
- labelling pen or 2 labels
- a metal bowl or heat-proof dish
- a heat-proof mat
- vinegar
- carb soda (sodium bicarbonate). You should have your own pack for experiments. If you have to use the pack from the kitchen, put a tablespoonful into an old container. You cannot put the carb soda back into the kitchen pack after the experiment.
- 2 teaspoons
- a microwave oven
- very hot water, for example from the kettle.

What to do:

1 Pour about 1 cm depth of vinegar into each cup. Label one cup as 'cold' and the other as 'hot'.

2 If you have a microwave oven, you can warm the vinegar in the 'hot' cup for about 10 seconds.

OR

Put the heat-proof dish on the heat-proof mat and stand the 'hot' cup in the dish. Carefully pour hot water into the dish around the cup to a depth of about 3 cm. (Don't put in so much hot water that the cup begins to float!) Leave it for about two minutes to warm the vinegar.

3 Measure about 1/2 teaspoon of carb soda onto each spoon.
You need to hold a spoon in each hand. Drop the carb soda into both cups at the same time and watch what happens.

Reporting on your experiment

Your experiment involved two separate tests.

Activity: Heating some vinegar and …

Based on your practical activity answer the following questions.

Everything in each test should have been the same, except one thing.

1 What was the thing – the **variable** – that was different?

The only difference should have been that you heated the vinegar in one test but not the other.

The variable you are investigating is the temperature of the vinegar.

Your experiment was a controlled experiment because you kept everything from changing in the tests except the temperature of the vinegar. The test where you did not heat the vinegar is called the control.

2 Which test tube (or cup) was the control in your experiment?

Now think about what happened.

3 How were the results of the two tests similar?

4 How were the results of the two tests different?

5 How does heating vinegar change the results in this experiment?

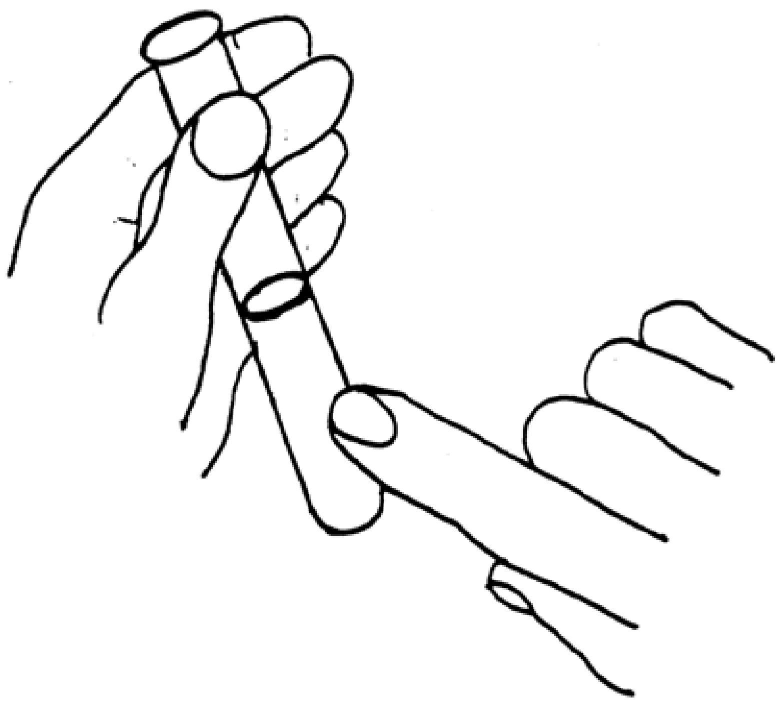
Check your response by going to the suggested answers section.

Is this a physical or chemical change?

So far, you've look for a new substance to decide if a change is chemical or physical. Is there a new substance made in this experiment?

Mixing vinegar and carb soda makes bubbles of a gas called carbon dioxide. This is a new substance – it is different from vinegar and carb soda.

So this must be a chemical change. There is another thing that suggests that this is a chemical change. Hold the test tube with warmed vinegar up to the light and tap it with your finger.



Shaking a liquid in a test tube

You should be holding the test tube near the top with your thumb on one side and your first and second fingers on the other side. Tap the bottom of the test tube sharply with the index finger of your other hand.
You should see the mixture in the test tube 'slosh about' – this will make it easy to see if there is any carb soda left.

Can you see any carb soda? If you can, is there as much as you put in?

You can usually observe that some or all of the original substances disappear in a chemical reaction.

Cleaning up

Your experiment is not finished until you have cleaned up your workspace and washed your equipment.

1 Did you use carb soda from the kitchen and put some into an old container? Is there any left over? Chemicals should never be put back in their original packets. Never mix chemicals with household products. Dispose of the carb soda by washing it down a sink or drain. Also wash away the mixture of carb soda and vinegar in your test tubes.

2 Get the test tubes, the beaker and your spatulas or spoons. Take them to an outside tap and wash them. You can dry them with a rag (not a kitchen tea towel) or leave them to dry if they are not left where young children can reach them. Store them away when they are dry.

3 Wipe over your heat-proof mat and spirit burner, then put them and the rest of your equipment away.

4 Wipe over your workspace with a damp sponge. If necessary, you can dry your workspace with a rag.

5 Take your sponge and rag to an outside tap and wash them out. Peg them on the clothesline to dry. You can put them away when they are dry.

6 Have a look at your workspace. Have you left it clean and tidy? You are a good scientist if you have!

Go to the exercises section and complete the Exercise 3.5: Physical and chemical changes crossword.

What did you achieve?

Tick what you can do.

❒ explain the difference between a physical change and a chemical change

❒ demonstrate safe work practices while carrying out a first-hand investigation

❒ demonstrate hygienic work practices by leaving your workspace clean after finishing an investigation.

Suggested answers – Part 3

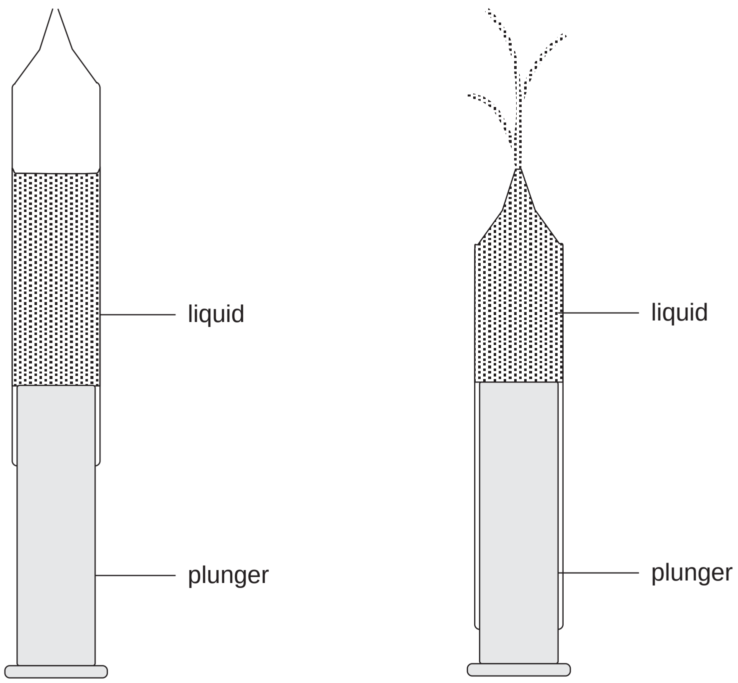
Check your responses against these suggested answers.

Looking at ice

Here are reasons why everything except the beaker are unsuitable.

- The filter funnel has a hole through it. It is not a container.
- The safety goggles would hold ice but you should be wearing them not using them as a container.
- The clock glass would hold the ice but as the ice melts water would run over the rim (edge) of the clock glass.
- The measuring cylinder is a container but it has a small opening only. It would be difficult to put ice cubes into a measuring cylinder.
- Like the measuring cylinder, the test tube is a container with a small opening. It would be difficult to put ice cubes into it.

Investigating liquid in a syringe



1 a The liquid is at the bottom of the syringe.

b If you try to squash the liquid it is squeezed out of the syringe.

2 If the syringe only contains water and the hole is blocked the water cannot be compressed.

Summary

1 The three states of matter are solid, liquid and gas.

2 It is easy to compress a gas.

3 A solid has its own shape.

4 A liquid does not have its own shape and it is difficult to squash, or compress.

5 Water vapour changes into liquid water when it gets cooler.

6 Liquid water forms a solid called ice when it cools.

7 Ice melts to liquid water when it gets warmer.

8 Water turns to water vapour when it is heated.

Changes of state

1 a Freeze means to change state from *liquid* into *solid*.

b Condense means to change state from *gas* into *liquid*.

c Melt means to change state from *solid* into *liquid*.

d Evaporate means to change state from *liquid* into *gas*.

e Boil means to change state from *liquid* into *gas*.

2

Word	**Present tense**	**Past tense**	**Name of process**
freeze	freezes	froze or frozen	freezing
condense	condenses	condensed	condensation
melt	melts	melted	melting
evaporate	evaporates	evaporated	evaporation
boil	boils	boiled	boiling

3
- Water is usually a liquid. It can *freeze* into a solid called ice. Then *melting* can change ice back into a liquid.
- Water can also *evaporate* or *boil* forming a gas called water vapour.
- When water *boils*, this change to a gas happens quickly.
- But as the gas cools again, it *condenses* back to water.

Heat and change of state

1

$$\text{solid} \underset{\text{– heat}}{\overset{\text{+ heat}}{\rightleftharpoons}} \text{liquid} \underset{\text{– heat}}{\overset{\text{+ heat}}{\rightleftharpoons}} \text{gas}$$

2

$$\text{solid} \underset{\text{temperature decrease}}{\overset{\text{temperature increase}}{\rightleftharpoons}} \text{liquid} \underset{\text{temperature decrease}}{\overset{\text{temperature increase}}{\rightleftharpoons}} \text{gas}$$

3

$$\text{solid} \underset{\text{freezing}}{\overset{\text{melting}}{\rightleftharpoons}} \text{liquid} \underset{\text{condensation}}{\overset{\text{boiling or evaporation}}{\rightleftharpoons}} \text{gas}$$

Modelling a liquid

Your answer should be similar to the one below. Read this sample answer and check that your answer has the same meaning.

The particles in a liquid are close together. There is very little space between particles so the particles cannot be pushed closer together. Therefore, a liquid cannot be compressed.

Checking the steps

2 Look for a pattern in the observations.

1 Observe the properties of solids, liquids and gases.

4 Test if the model can explain other observations.

3 Make a model that explains the observations.

Heat and changes of state

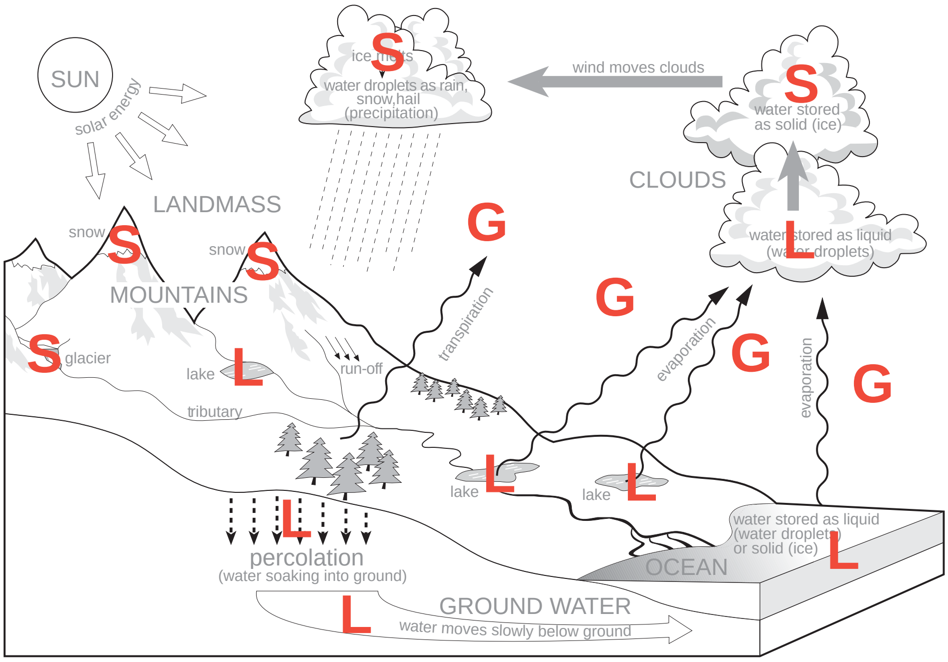
1 Gas

2 Solid

3 Evaporation, boiling, melting.

4 Condensation, freezing.

Water cycle diagram



Heating some water

The best statement is:

2 Burning is a chemical change because new substances are made.

The first answer is incorrect because new substances have been made and new substances are not made in a physical change.

The third answer is correct but the reason seems like a description of a physical change not of a chemical change.

Reviewing physical and chemical changes

1 In this lesson, I've learned about two kinds of changes.

A change of state is a physical change because there are no new substances made.

New substances are made in a chemical change. Burning is an example.

2 When water boils, it changes to steam, or water vapour.

When steam hits a cold mirror, it condenses into water.

When washing dries, water evaporates and becomes water vapour.

Freezing water makes ice and melting ice makes water.

These are all examples of physical changes.

Safety check test

1. When heating liquids in a test tube, you should hold the test tube in a test tube holder.
2. The test tube should be no more than half full.
3. When the test tube is heated it should be tilted.
4. The mouth of the test tube should never be pointed at anyone.
5. To heat the liquid evenly, you should move the test tube around.
6. Sometimes liquid will spurt out of a test tube during heating. Safety goggles would protect your eyes from being burned or damaged by the chemicals if this happened.
7. No, you should not use a glass for heating. It is not made of special glass like a test tube (or beaker) and might crack or even explode.

Heating some vinegar and …..

2. The test tube (or cup) labelled 'cold' is the control in the experiment. It is the test that was not heated in the experiment.
3. The results of the two tests were similar because they both fizzed (made bubbles).
4. The results of the two tests were different because:
   - the 'hot' test fizzed more than the 'cold' test
   - the 'hot' test began fizzing before the 'cold' test
   - the 'hot' test stopped fizzing before the 'cold' test stopped
   - the 'hot' test happened more quickly than the 'cold' test
   - the 'hot' test used up all the carb soda but there was some left in the 'cold' test.
5. Heating the vinegar makes the substances change quickly into new substances. It speeds up the change.

Exercises – Part 3

Exercises 3.1 to 3.5 Name ______________________________

Teacher ______________________________

Exercise 3.1: Working safely with chemicals

Imagine you are doing an experiment where you heat some vinegar in a beaker then add some strips of metal. The vinegar and metal react producing bubbles of gas.

You catch some of the gas in a test tube and make it explode with a squeaky pop when you light it. The experiment is so much fun that you decide to show it to your little sister.

Think about safety!

1 What safety equipment will you use during the experiment? Explain why you would use each safety device. Think of at least two things.

- I'd use ______________________________

  because ______________________________ .

- I'd use ______________________________

  because ______________________________ .

- I'd use ______________________________

  because ______________________________ .

2 What would you do to keep your little sister safe when she was watching the experiment?

____

____

____

____

Exercise 3.2: Energy content of foods

An adult who is very physically active may need ten million joules per day – that's 10 000 kJ per day. The table below gives sample values for a range of foods and drinks.

1 Complete the table with information from eight packaged foods that you eat by looking at the nutrition information tables on the packages.

Food or drink	**Energy (kJ/100g)**	**Food or drink**	**Energy (kJ/100g)**
oils and fats	3700	egg	600
nuts	2400	yoghurt	350
potato crisps	2300	fruit/vegetables	100-200
cake/pastries	2000		
cheese	1700		
meat	1500		
hamburger	1200		
pizza/bread/fish	1000		
fried rice	800		
alcohol	2900		
water	0		

2 Use the information in the table and nutrition information tables to estimate what your energy intake is in a day. You could do this by:

- writing down the quantity of all that you ate and drank yesterday
- estimating how many kJs this quantity provides you with
- adding together the kJs to get the total intake in one day.

Note that if food is cooked in oil or fat this raises the energy content considerably. Potato has about 150 kJ/100g but if cooked in fat or oil (3700 kJ/100g) as potato crisps the energy content increases to 2300 kJ/100g.

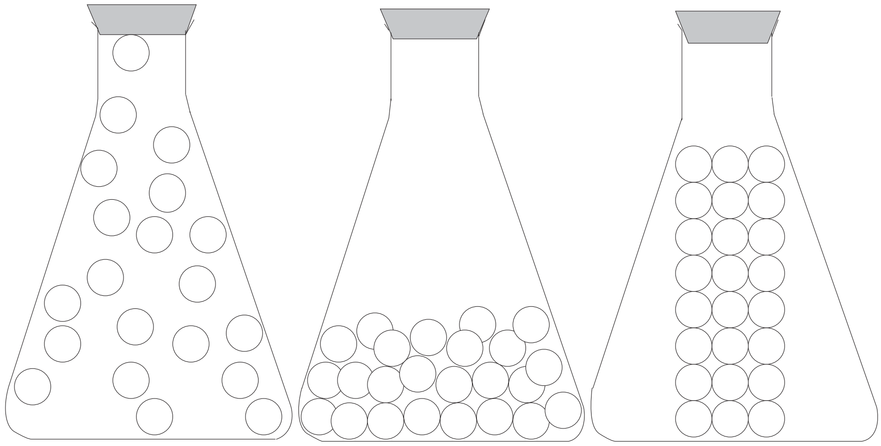
My estimate of my energy intake per day is ____________________ kJ.

Note that nutrition tables also give other information. Your diet must not just provide energy – it must also provide a range of suitable chemical nutrients.

Exercise 3.3: Explaining the states of matter

1 Here are diagrams representing a solid, liquid and gas.

a Which is the solid, liquid and gas? Label each diagram on the line underneath.



_______________ _______________ _______________

b Which theory has been used to draw these diagrams?

2 Here are some statements about the particle theory of matter.

a The particles in water are the same in all states of matter

b Particles in solids and liquids are close together but particles in gases are separated.

c Particles are packed into a fixed pattern in solids.

d Particles in gases can move much more than particles in liquids.

Match each observation below with the statement (a, b, c or d) that best explains it.

i Solids have their own shape. _____________

ii Liquids and solids cannot be compressed. _____________

iii Water can be a solid, liquid or gas. _____________

iv Gases fill the container in which they are stored. _____________

Exercise 3.4: Examples of working scientifically

The column on the left hand side lists some steps that scientists follow when they work scientifically. The steps *are* in the correct order.

The column on the right hand side contains examples. They *are not* in the correct order.

Draw a line from each step on the left to a matching example on the right.

Scientists work scientifically by:	an example is:
1 Making observations	the idea that substances are made up of very small particles
2 Finding patterns in observations	combining ideas about matter made up of particles to get a model that can be tested by further observations
3 Suggesting an idea or model to explain the observations	grouping substances as solids, liquids and gases
4 Testing the idea or model	using the model to explain the properties of solids, liquids and gases
5 Applying the idea or model to predict	look at how substances can change state

Exercise 3.5: Physical and chemical changes crossword

Complete the crossword puzzle.

Across:

2 Making liquid from gas

5 A change where you would make a new substance or notice that an original substance disappeared

6 When a solid becomes a liquid

7 A physical change forming a solid

8 Something that can be changed in an experimental procedure

9 In a fair test, the results _______ on the one variable you change.

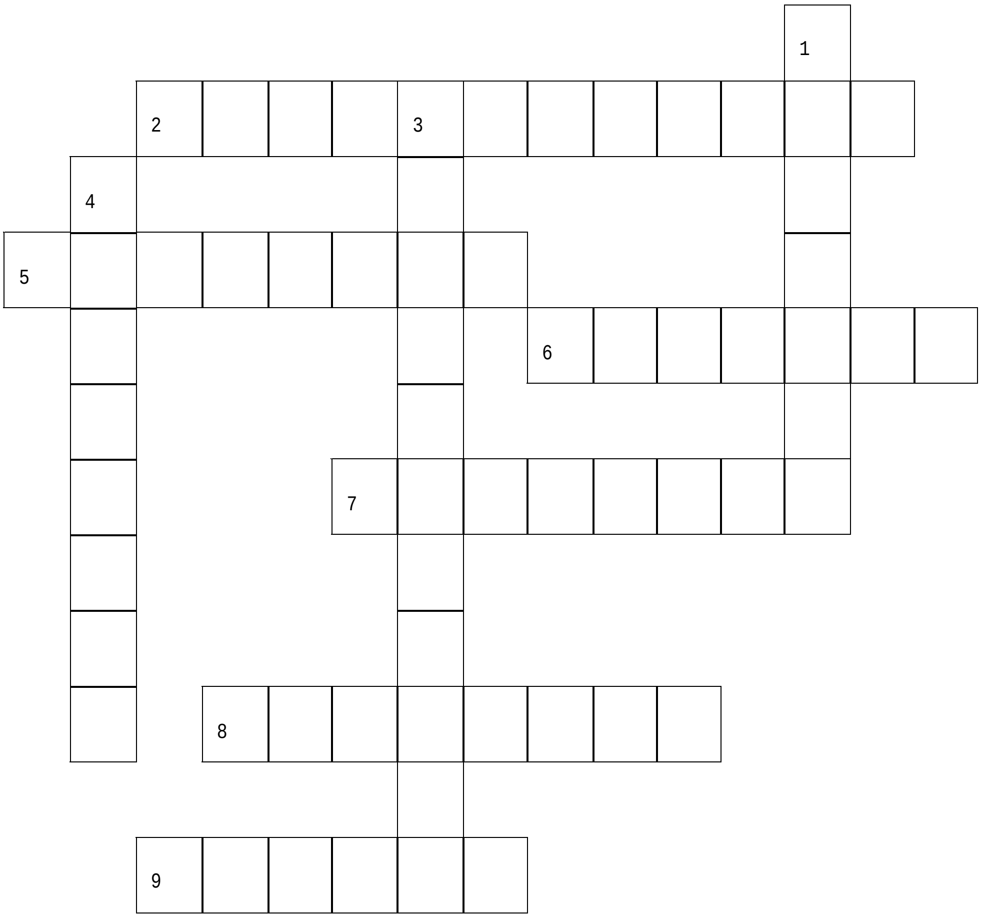
Down:

1 When bubbles of gas form quickly in a liquid as it changes state

3 When a liquid changes to gas

4 A change where no new substance is formed.

When you have completed the crossword, shade over each word in the puzzle that describes a physical change.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