Mrs Lawrence's

7/8X Science

# PARTICLES

Theory Booklet

Name: ____________________

# HOW TO USE THIS BOOKLET:

- Read the information provided within the booklet
- Answer the guided activities
- Where you have the required equipment, try to complete the prescribed activities.

  *This will make the lesson content much more interesting, and will help you to understand the concepts being covered.*

- Complete the matching questions within the Assignment Booklet

  *If you are having trouble answering them, you can:*

  - ✓ *Call Mrs Lawrence at school on 6785 1184*
  - ✓ *Email Mrs Lawrence at Ariana.lawrence@det.nsw.edu.au*
  - ✓ *FB Messenger Mrs Lawrence as Ariana Lawrence*
  - ✓ *Arrange for a tutorial session with Mrs Lawrence at the school library*

- Submit the Assignment Booklet to Mrs Lawrence for Marking

## DUE: 15th May 2020

# Science
# Stage 4
## Modelling matter
## Part 1

Education & Communities

Distance Education Science Network

## Acknowledgments

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# Contents

# Outcomes

By completing this part, you are working towards achieving the following outcomes:

- identify questions or problems that can be tested or researched and make predictions based on scientific understanding
- produce a plan to investigate identified questions, hypotheses or problems, individually and collaboratively
- follow a sequence of instructions to safely undertake first-hand investigations to collect valid and reliable data and information, individually and collaboratively
- process, analyse and evaluate data from first hand investigations and secondary sources to develop evidence based arguments and conclusions
- present science ideas and evidence for a particular purpose and to a specific audience using appropriate scientific language, conventions and representations
- describe the observed properties and behaviour of matter using scientific models and theories about the motion and arrangement of particles

The following are taken from the Board of Studies NSW Syllabus for the Australian Curriculum SCIENCE Years 7 - 10, 2013

Content Statements:
WS4a, WS4b, WS5.1a, WS5.1b, WS5.1c, WS5.2a, WS5.2c, WS5.2d, WS5.3a, WS5.3b, WS6a, WS6b, WS6c, WS6d, WS6e, WS7.1a, WS7.1b, WS7.1c, WS7.1d, WS7.2a, WS7.2c, WS7.2d, WS7.2e,WS8e, WS9a, WS9b,WS9d, CW1a, CW1b, CW1c, CW1d, CW1e

# Resources

Here is a list of materials you will need to gather from home to use in Parts 1 and 2

**Part 1**

2 glasses
Ice cubes
2 plastic lids (from storage containers)
Cotton wool ball or tissue

**Part 2**

2 pegs
Wire coathanger
Plastic cup
Tissue
Large container (eg ice-cream container)
Square of thick cardboard (10 cm x 10 cm)
2 identical glasses
Kitchen scales

You will also be supplied with a mini-kit for Parts 1 and 2.

The modelling matter mini-kit contains the following items:

2 paddle pop sticks
Pipette
Blue, yellow and red coloured sugar crystals
Thermometer
2 balloons
2 metal cubes
USB with various videos

# Icons

Write a response or responses as part of an activity. An answer is provided so that you can check your progress.

Compare your response for an activity with the one in the suggested answers section.

Complete an exercise in the exercises section that will be returned to your teacher.

Think about information or ideas. You need to pause and reflect. You may need to make notes.

Perform a practical task or investigation.


Stop and consider the risks to safety for yourself and others.


Use the USB sent to you for the topic

# Glossary

Here is a list of the key terms used in this unit.

| | |
|---|---|
| **boiling point** | temperature at which a substance changes from a liquid to a gas |
| **change of state** | process by which matter changes from one state to another |
| **condensation** | the process where a gas changes state to a liquid |
| **contraction** | becoming smaller or decreasing in size or volume |
| **density** | measure of mass per volume of a substance |
| **diffusion** | process where one substance is thoroughly mixed in another |
| **evaporation** | the process where a liquid changes state to a gas |
| **expansion** | becoming larger or increasing in size or volume |
| **freezing point** | the temperature at which a liquid changes state to a solid |
| **heat** | a form of energy. Heat energy is released when a fuel burns |
| **mass** | the amount of matter in a substance. Mass is measured in grams, kilograms or tonnes |
| **melting point** | the temperature at which a solid changes state to a liquid |
| **prediction** | a forecast based on scientific understanding or observations |
| **solution** | a mixture in which one substance dissolves in another |
| **temperature** | a measure of how hot a substance is |
| **weight** | the force due to the action of gravity on the mass of a substance. In science it is measured in Newtons |

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# Lessons 1 and 2: What is matter?

Everything around us is made of matter – trees, houses, soil, all appliances, our houses, the air we breathe and the water we drink. From the time of the ancient Greeks, humans have speculated and debated about the nature of matter. What is all this ‘stuff’ made of and why does it have certain characteristics?

For instance, we can pour water into a glass but not ice. Ice can’t be poured into a glass because it has a shape, and if it is kept cold, ice will keep its shape.

A scientific definition of matter is anything that has mass and occupies space.

Think about water as an example of matter.

Does water have mass and does it take up space?

A bucket of water is pretty heavy to lift. So it definitely has mass. It also takes up space in the bucket. Since it has mass and takes up space, water is matter.

Water is a liquid. A liquid is one of the common states of matter. The other two common states of matter are solid and gas.

To find out how a solid, liquid and gas differ we need to look deep inside matter at a very small scale.

## Matter is made of very small particles

Chemists know that matter is made of very small particles. There are very powerful microscopes that enable us to see particles. However, the particles are so small that it is difficult for us to imagine.

For instance in one tablespoon of water there are about 600 billion trillion water particles! The particles are huge in number and incredibly small in size.

While we can’t see the particles with our eyes, we can see the results of how they behave and interact by making some observations.

From these observations we can make inferences about how the particles might be arranged.

## Activity 1 – Drops of water

The question we will investigate is:

Does water hold together well?

Materials you will require are:

- Water in a small cup
- Dropper
- Paddle pop stick
- Plastic lid (from a storage container)

**Procedure**

1. Use a dropper to gently squeeze out one drop of water but try not to let the drop fall completely out of the dropper. See how far you can make the drop hang off the the end of the dropper without the drop falling.

2. Place 4 or 5 drops of water together on the plastic lid to make a large drop.

3 Gently tilt the lid in different directions so that the drop moves.

4. Use a paddlepop stick to slowly move your drop around the plastic lid. Try using the stick to separate the drop into two drops.

5. Use the stick to move the two drops near each other. Then move one drop so that the two drops touch.

**What did you observe?**

1. When you squeezed the water drop out of the dropper, did the water hold together or break apart?

   ______________________________________________

2. When you were pulling the drop around the plastic lid, did the water seem to hold together or come apart easily?

   ______________________________________________

3. When you tried to split the drop, did the drop separate easily?

   ______________________________________________

4. Was it easy or difficult to make the drops come together?

   ______________________________________________

*Compare your responses with the ones in the suggested answers section.*

What did your observations tell you about the question 'Does water hold together well?'

5. Circle the sentence which best matches your observations.

| |
|---|
| Water *does* hold together well. |
| Water *does not* hold together well. |

*Compare your responses with the ones in the suggested answers section.*

## Particles in water are attracted to each other

This investigation tells us that water holds together well. Why does water hold together – what is happening between the particles of water to keep them together?

We can infer that the particles of water are attracted to each other. The attraction between the particles can explain why it is difficult to separate a single drop of water into two drops and why, when two drops of water touch, they quickly and easily combine.

The photographs below show the result of the attraction between particles in water.

The photographs have been taken with very high speed film showing what happens immediately after a water-filled balloon is pierced with a pin.

The body of water retains it's shape quite well the moment the balloon is popped because of the attraction between the particles.

Eventually the force of gravity will overcome the force of attraction between the particles and the water particles will fall to the ground.

## Activity 2 – Particles in motion

The particles in liquid water are very small and they are attracted to each other.

Can we detect if the particles are in motion? Are the particles moving?

To complete an investigation to see if any movement can be detected you will need to collect the following materials:

- A tall clear glass
- Tap water
- Red coloured sugar crystals

**Procedure**

1. Add water to the glass until it is about ¾ filled.
2. Add the red coloured sugar crystals. Do not stir.
3. Observe closely.

**What did you observe?**

1. Circle the words that best describe what you observed.

> Without being stirred the colour *slowly mixed/ did not mix* into the water.

*Compare your answer with the one in the suggested answers section.*

You will see that the food colouring in the sugar mixes in with the water. This is because the water particles are moving around. When they move, the water particles push the red coloured particles in all directions. Eventually the red colouring will mix evenly through all the water.

**2.** Below are two photographs that show this investigation but using food colouring (liquid) instead of coloured sugar crystals

Write a caption under each photograph that describes what each represents in the investigation.



| *Caption 1* | *Caption 2* |
|---|---|
| | |

*Compare your answer with the one in the suggested answers section.*

## A model of particles in liquid

Models are often used in science to help us understand the world and the way it works.

Computer models are commonly used to predict the movements of tides and tsunamis, or the effect on coastal areas of a small rise in sea levels.

Sometimes physical models are used, such as this model of the heart. This allows us to study the structure of the heart without having to dissect one.

Scientific models can be used to represent things that might be too large or impossible to fit into one room.

World globes are used to represent the earth because we cannot fly into space every time we need to look at it.

We can use models to represent things that are too small to see normally, such as a model of a cell or a model of particles in a liquid.

This is a diagram of a model of the arrangement of particles in a liquid.

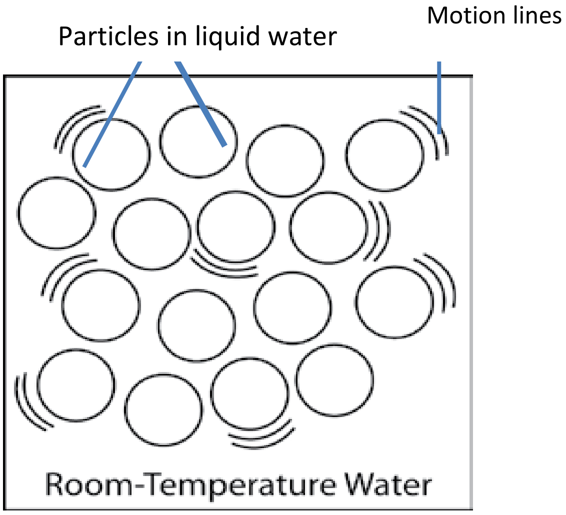
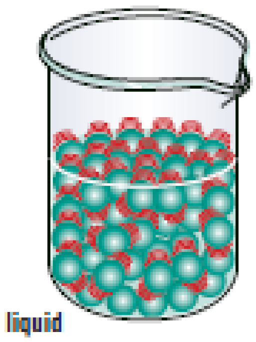



Diagram of the particle model of a liquid

The model of particles in a liquid says:

- particles are in constant motion (curved lines are drawn to represent motion)
- particles are attracted to each other
- particles are not arranged in any particular order
- particles can move past each other but their attractions keep them from moving far apart from each other.

To be useful, a model must be able to explain our observations. A model is useful if it can help us understand and predict how a liquid behaves. The particle model can explain why water holds together well, why food colouring mixes thoroughly with water and why water flows to take the shape of the bottom of its container.




In a liquid such as water, the particles are not in a fixed shape and can slip freely around each other. This explains why liquids such as water can be poured. The particles slip past each other.

## Evidence for the particle theory - Brownian motion

Brownian motion was named after Robert Brown, a Scotsman who first described it.

Robert Brown lived at the time when Australia was first colonized in the late 1700's and early 1800's. He was very interested in nature, particularly plants, and became well known in England as an authority on plants.

He became so well known for his thorough work on plants that he was chosen to accompany Matthew Flinders on the three year voyage to circumnavigate Australia in 1801. Brown's role on the voyage was to record and take samples of plants and animals that were found on the uncharted continent and then return to England with this information.

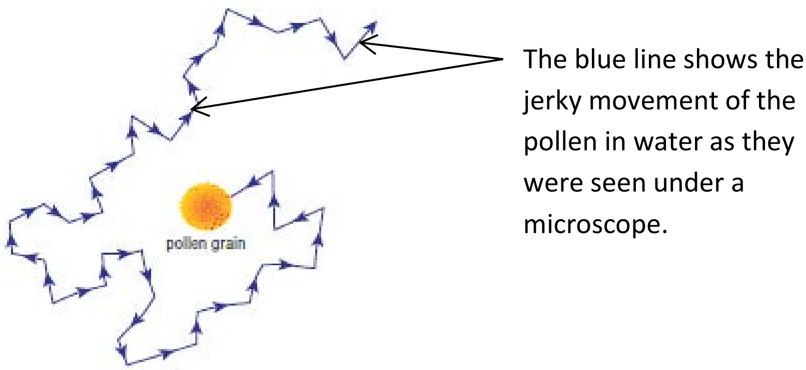
Brown used a microscope in his later study of plants. It was when he was studying pollen grains under the microscope that Brown first noticed continuous jerky movements of pollen.

Pollen is found on the flowers of plants. Every plant has its special type of pollen. Bees collect pollen to make honey. Pollen is very small, it is microscopic. Here is a photograph of a bee with pollen covering the hairs on its legs and underbody. The big yellow sacks are the pollen sacs. The bees push the pollen into the sacks to transport back to the hive.

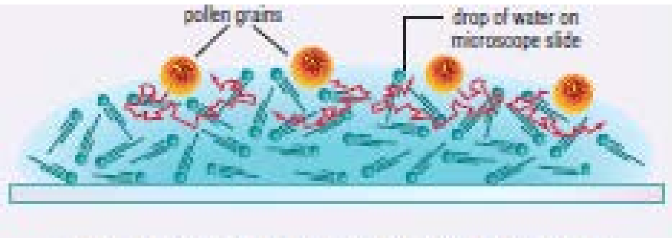

To look at pollen under the microscope, Brown made a slide and put the pollen in a drop of water.

Brown was intrigued by the continuous movement of the pollen in the water. He meticulously recorded the continuous, jerky movements of the pollen and published his observations.

However he had no theory to explain his observations. Brown knew the pollen wasn't alive so it wasn't moving on its own, so what was making the pollen move?



About 50 years later other scientists explained his observations using the theory that matter is made of particles that are in constant motion.




Red wriggly lines show how the pollen moved.

The blue lines represent the movement of the water molecules

This is a diagram of a microscope slide showing the pollen in a drop of water. The particles in the water are colliding with the pollen and moving them in all directions.

## Activity 3 – Explaining Brownian motion

Use the words below to complete an explanation of Brown's observations by using the theory that matter is made of particles.

| | | | | |
|---|---|---|---|---|
| moving | microscope | particles | directions | collide |

Brown studied pollen under a microscope. He made a slide by putting the pollen in water. When looking at the pollen slide under a _______________,

Brown observed the pollen was _______________ continuously and randomly in jerky movements.

These observations can be explained by the theory that water is made of very small _________________ that are constantly moving. The moving particles ______________ with the pollen and push them around in all _________________.

*Compare your answer with the one in the suggested answers section.*

## Summary

- Everything around us is made of matter.
- A definition of matter is anything that takes up space and has mass.
- The three normal states of matter are solid, liquid and gas.
- The particle model can be used to explain the behaviour of liquid water.
- In a liquid, the particles:
    - are attracted to each other
    - are arranged in no particular order
    - are in constant motion
    - can slip past each other but not move too far apart from each other.

### EXERCISE

**Complete the exercises for Lessons 1 and 2 in the Send-in exercises**

# Lesson 3: Temperature and motion of particles

Last lesson we observed the particles in red colouring mixing evenly throughout water.

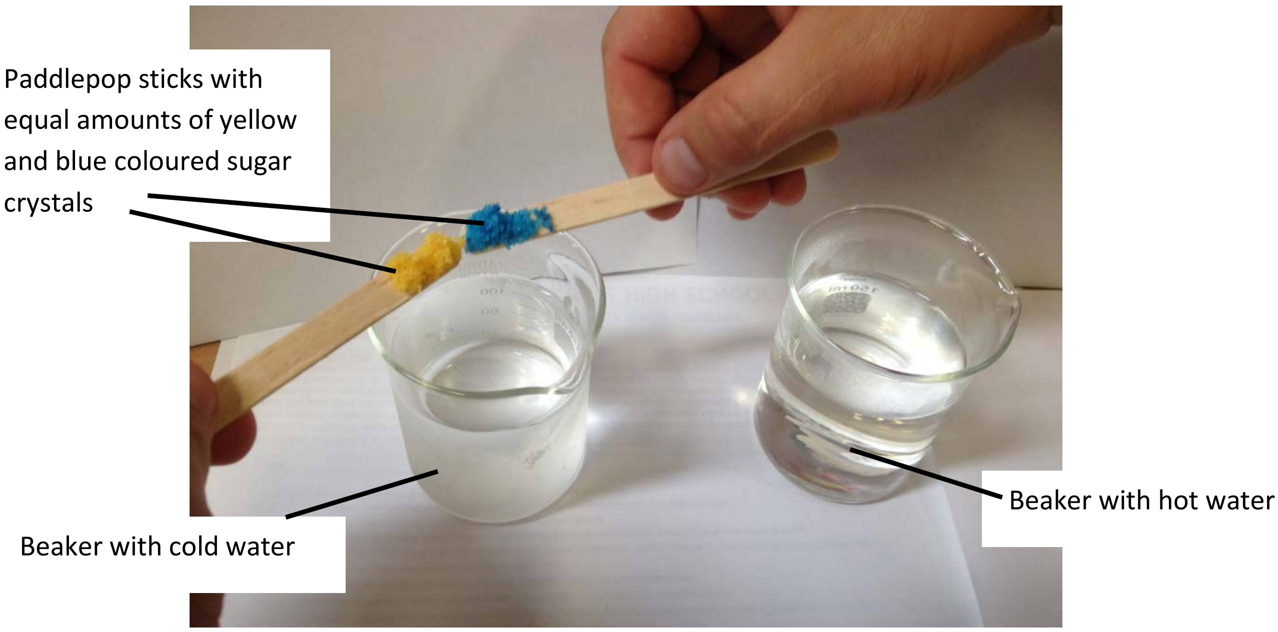
The scientific term for this process is diffusion. Diffusion occurs because of the constant movements of the particles.

Diffusion is explained because the particles in water are constantly moving and pushing the food colouring around until it is evenly spread throughout the water.

So far we have used room temperature water to observe the effect of moving particles.

Will the speed of water particles be different in hot water compared to cold water?

We can design and perform an experiment to answer this question by using sugar crystals soaked in food colouring and hot and cold water.



## Activity 4 – Diffusion in hot and cold water

The aim of this investigation is:

To compare the rate of diffusion of food colouring in hot water and in cold water.

**Materials**

- Two identical clear glasses or tumblers
- Sugar crystals soaked in blue food colouring and yellow food colouring
- Hot tap water
- Ice in some cold water

What do you predict the results of the experiment will show?

There are two possible results described below:

1. a difference will be observed in the rate of diffusion; or
2. no difference will be observed in the rate of diffusion.

Your prediction will be based on your past experiences with hot and cold water. Which possible result did you choose?

**Setting up the experiment**

In this experiment we want to see the effect of the temperature of the water on the rate of diffusion.

We will be observing or measuring the rate of diffusion.

We will be changing the temperature of the water. This is the only thing that will be different.

Everything else must be kept the same.

Consider the following questions before you set up the experiment:

- Will you use the same amount of water in each glass?
- Will you use the same size and shaped glass for the hot water and cold water?
- Will you use the same amount of coloured sugar crystals in each glass?
- Will you put the coloured sugar in each glass at the same time? (or as nearly as possible)

  The answer to all of these questions is yes.

All parts of the experiment need to be kept the same, except for one thing.

In this case the only factor or thing we are changing is the temperature of the water, everything else is the same.

**Procedure**

1. ¾ fill a glass with cold water (use ice if you wish to make the water colder).
2. Measure and add the same quantity of hot water to the second glass.
3. Using your paddlepop sticks, add the same amount of yellow and blue coloured sugar crystals to the glass with cold water and then as quickly as possible add the same amount of yellow and blue coloured sugar crystals to the glass with hot water.

5. Observe and record results.

**Results**

Below are the expected results. How do we know these are the expected results? This experiment has been repeated many times with the same results.

- In hot water the blue and yellow colouring spread faster than in cold water.
- In hot water the colours combined and turned green more quickly than in cold water.
- In cold water the colours remained separate for longer than in hot water.

Were your results the same as the expected results above? If they weren't similar, it doesn't mean that you are wrong. It most probably means there wasn't a big enough difference in temperature between the hot and cold water that you used.

**Conclusion**

Write a conclusion for this experiment. Remember a conclusion is a brief sentence that relates to the aim.

*Compare your answer with the one in the suggested answers section.*

**Discussion**

Think about the theory that a liquid is made of particles that are attracted to each other and constantly moving.

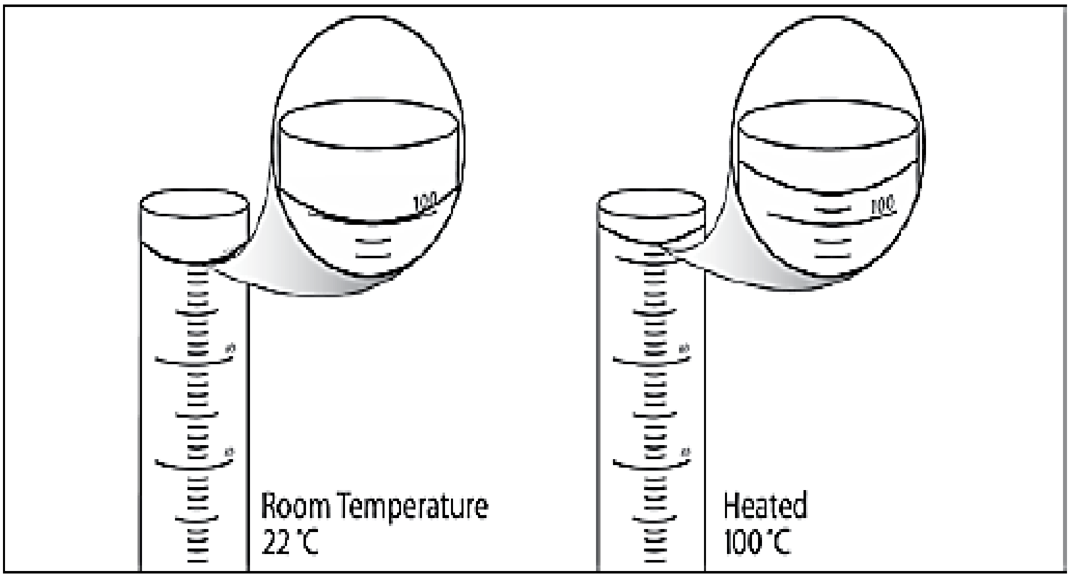
What do the results of the experiment tell us about the movement of particles in hot water compared to the movement of particles in cold water?

The particles are moving faster in hot water than they are in cold water. This was shown by the food colouring in hot water mixing faster than the food colouring in cold water.

## Hot water takes up more space

Imagine that you measure exactly 100mL of water in a measuring cylinder. This water is at room temperature 22°C.

You then heat the water to 100°C and notice that the volume increases to 104mL.




The particles in hot water are moving faster but they are also further apart from each other. The space between the particles increases in hot water.

## Activity 5 - Particles in hot water and cold water

Complete the sentences below by writing either the word *increases* or *decreases.*

1. Heating a liquid ___________________ the motion of particles.

2. Cooling a liquid ____________________the motion of particles.

3. As the motion of particles increases, the space between the particles

   _________________ .

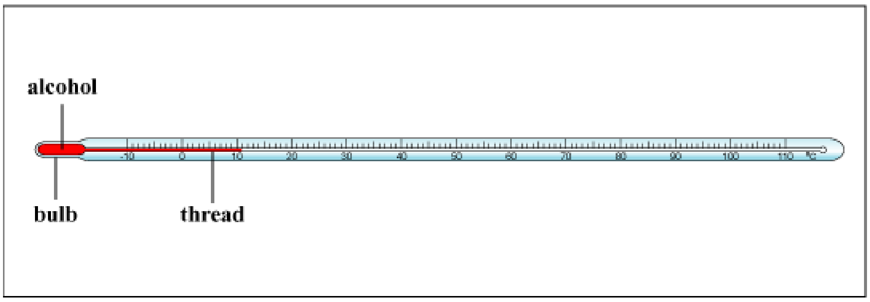
4. As the motion of particles deceases, the space between the particles

   ___________________.

*Compare your answer with the one in the suggested answers section.*

## Thermometers and the motion of particles

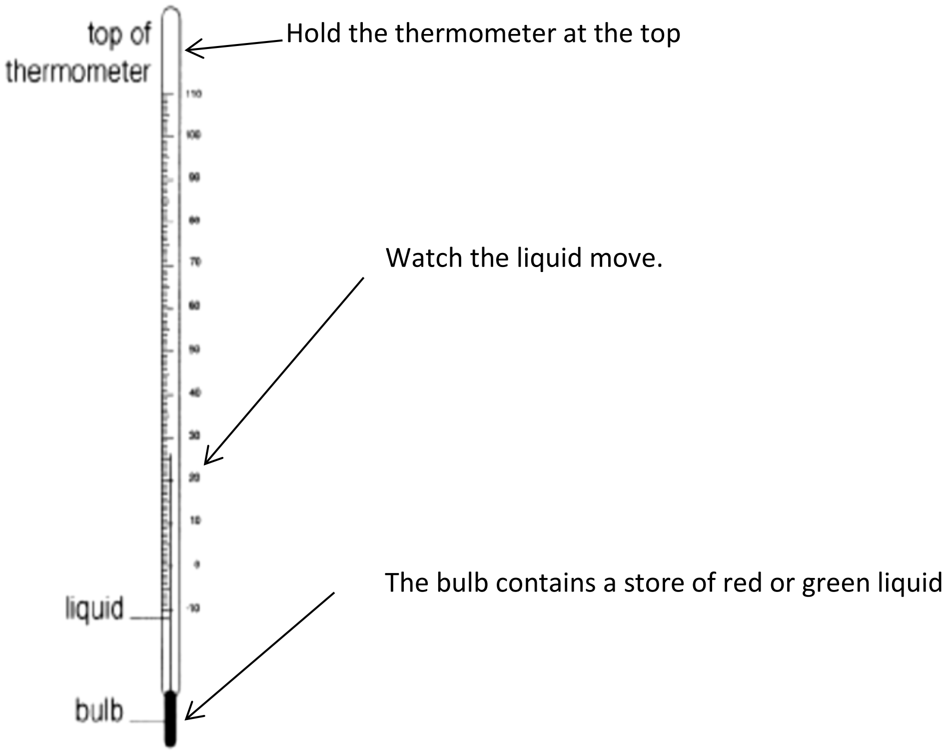
A thermometer is an instrument that measures temperature. A thermometer used in schools has a thin red tube of liquid. The liquid is a type of alcohol.



## Care and use of the thermometer

You will be supplied with a thermometer similar to the one shown below. Remember it is made of glass so it is fragile. Here are some guidelines for using this thermometer at home.

- Use only to measure temperature (not as a stirring rod or a probe).
- Do not expose it to extreme changes in temperature (i.e. do not immerse it in boiling water immediately after it has been in iced water)
- When placing the thermometer in a liquid or against a solid it will take time for the liquid inside the thermometer to stop moving.
- Thermometers roll. Do not lay the thermometer down where it may roll off the table top and fall.



## Activity 6 – Observing the red or green liquid in a thermometer

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Collect these materials:

- Thermometer
- Hand lens
- Cold water
- Cotton wool ball or tissue
- Hot tap water in a cup

1. Look closely at your thermometer. The liquid is a type of alcohol that has been dyed red or green.
2. Practice observing the top of the coloured liquid by having your eye at the same level as the very top of the liquid.
3. Use the hand lens to carefully observe the thermometer and the top of the liquid.
4. Put your thumb and finger on the bulb and observe the coloured liquid. Does it move?
5. Dip the cotton wool in cold water and place it around the bulb of the thermometer. Does the coloured liquid move?
6. Place the thermometer in the cup of hot water and observe the liquid.

**Results**

Complete the sentence that describes what you observed.

The red liquid goes _________ in hot water and goes ___________ in cold water.

*Compare your answer with the one in the suggested answers section.*

### Explaining the results

Use the USB to watch the animation *heating and cooling a thermometer.*

If you are not able to use the USB, you can go to our school elearning site and watch the animation in the video book for Modelling matter in the Year 8 Science course.

Please call us if you have any difficulties accessing the elearning site.

When heated, the particles of the coloured liquid inside the thermometer move faster and spread a little further apart.

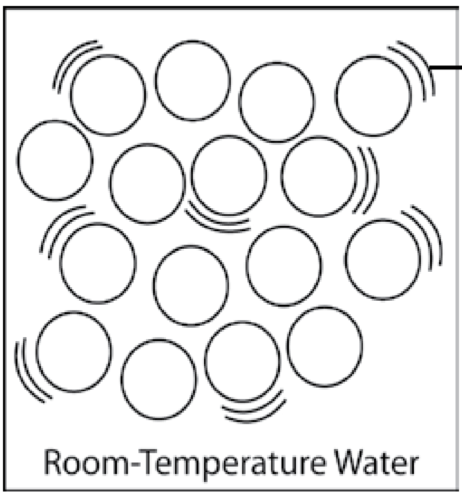
They have nowhere to go but up the tube.

When the thermometer is placed in cold water the particles slow down and come closer together.

The liquid moves down the tube.

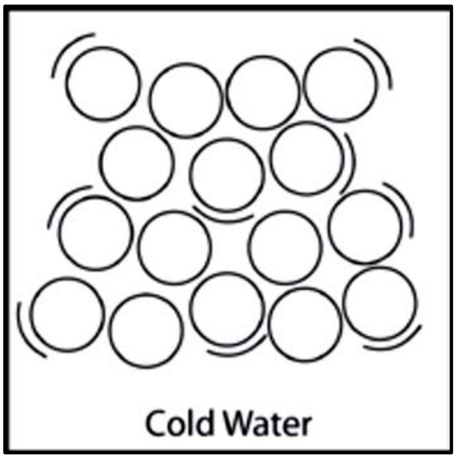
## Activity 7 - Using the model of particles

Remember the diagram below represents particles in a liquid at room temperature.




The curved lines represent the particles are moving.

Below is a diagram showing particles in cold water. The same number of particles is shown in both diagrams. There are two differences in the way the particles are represented in these two diagrams. What two differences can you see? Complete the sentences below.




One difference between the particles shown in the diagrams is ________________________

______________________________________

Another difference between the particles shown in the diagrams is _______________________

_______________________________________

Now consider drawing the particles in hot water compared to the particles in room temperature water.

Would the particles be closer together or further apart in hot water?

Would there be more or fewer motion lines in hot water than in room temperature water?

Complete the diagram below to show particles in hot water. Use the same number of particles as in the diagrams above (16 particles)

*Compare your answer with the one in the suggested answers section.*

## Expansion and contraction

When a thermometer is placed in hot water, the coloured liquid moves up the thin tube because the particles are moving faster and they are further apart. The particles take up more space.

The scientific term for the process of taking up more space is called expansion. The liquid takes up more space and we say it has expanded.

When the thermometer is placed in cold water, the coloured liquid moves down the thin tube because the particles are moving more slowly and they are closer together. The particles are taking up less space.

This process of taking up less space is called contraction. We say the liquid has contracted.

## Summary

- Particles in a hot liquid move faster than the particles in a cold liquid.
- Particles in a hot liquid are further apart than the particles in a cold liquid.

**EXERCISE**

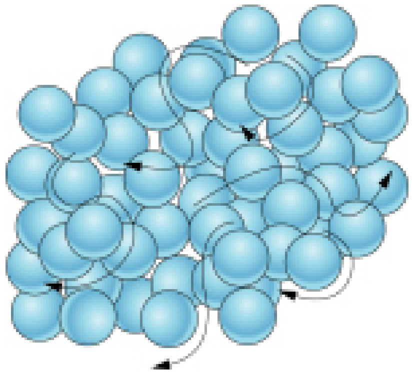
**Complete the exercises for Lesson 3 in the Send-in exercises**

# Lesson 4: Particles in a solid

In the work completed in the previous lessons, you investigated the behaviour of particles in a liquid.

By making observations you are able to say that the particles in a liquid are:

- attracted to each other
- in constant motion
- close together but they can slip past each other
- not arranged in a regular pattern



When heated, the particles in a liquid move faster and so spread slightly further apart.

When cooled the particles in a liquid move more slowly and so move a little closer together.

How are the particles arranged in a solid? Think about ice, the solid state of water.

Go deep inside the ice to think about how the particles might be arranged.

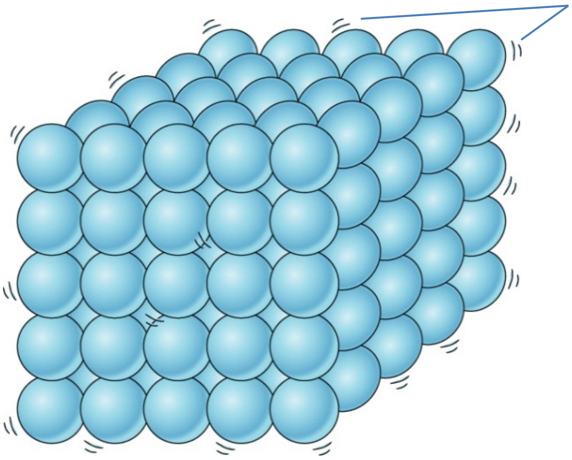
Do you think the particles of solid water are attracted to each other?

The answer is yes, the particles are attracted to each other.

Do you think the particles are close to each other?

The answer again is yes. In fact the particles are very close to each other. They are closer than in liquid water. As well, the force of attraction between the particles is greater than in a liquid.

Below is a model of the arrangement of particles in a solid.



This model shows motion lines. In a solid the particles vibrate backwards and forwards.

The particles are attracted to each other, they are close together and they are arranged in a regular pattern.

This is why solids retain their shape.

Watch the particle model animation *Comparing solid and liquid* by clicking on the link in the USB


Use the USB to watch the animation *particles in a solid*

If you are not able to use the USB, you can go to our school elearning site and watch the animation in the video book for Modelling matter in the Year 8 Science course.

Please call us if you have any difficulties accessing the elearning site

## How does heating and cooling affect a solid?

It is harder to show the effect of heating and cooling on a solid than a liquid.

However, there is a piece of science equipment called a ball and ring that is designed to demonstrate the effect of heating and cooling on a solid. The ball and ring are solid metal.

## Activity 8 – Demonstrating a ball and ring.

Below are the steps a teacher would follow when using the ball and ring to demonstrate the effect of heating and cooling a solid.

Read through the steps 1 -5 and think about what may be happening to the particles that could explain the observations.

1. Initially the ball will fit through the ring.

2. The ball is then heated in the flame of a Bunsen burner for one to two minutes. *What could be happening to the motion of the particles in the ball?*

3. After heating, the ball will not fit through the ring.

   *The ball is bigger, it has expanded. What does this say about the space between the particles and the motion of the particles?*

4. To cool it, the ball is placed in a beaker of water

*What is happening to the motion of the particles when they are cooled?*

5. After being in the water for a few minutes the ball will fit through the ring again.

**Results**

The observations are that when the solid metal ball is heated it will no longer fit through the ring. It has expanded.

When the metal ball is cooled it will once again fit through the metal ring.


Use the USB to watch the animation *heating and cooling solid*

If you are not able to use the USB, you can go to our school elearning site and watch the animation in the video book for Modelling matter in the Year 8 Science course.

Please call us if you have any difficulties accessing the elearning site.

**Questions**

a. We can explain these results by looking at what is happening to the particles when they are heated and then when they are cooled.

Use the words in the word bank to complete the following sentences that describe what is happening to the particles.

| | |
|---|---|
| expanded | further |
| big | vibrate |

i. When the ball is heated, the particles in the metal ___________ faster and they move ______________ apart from each other.

ii. When the particles move further apart the ball has__________.

It is now too ______ to fit through the ring.

b. What happens to the particles in the metal ball when the ball is cooled down in step 4?

Circle the phrases that describe what happens to the particles.

| | |
|---|---|
| get further apart | get closer together |
| vibration slows down | vibration speeds up |

*Compare your answer with the one in the suggested answers section.*

**Real world problems caused by expansion of solids**

Railway lines are a solid. They expand in hot weather so railway builders leave gaps between the sections of rail lines. This gives the lines room to expand.

The gaps in the lines give a train the 'clickety-clack' noise when the wheels run over the gaps.

If no gaps are left, the lines still expand in hot weather but because there are no gaps they would buckle.

When engineers design bridges they allow for the bridge to expand by having expansion joints every so often.

This allows the bridge to expand and contract safely without cracking.

Here is a photograph of a bridge in Denmark. In very hot weather this bridge expands by 4.7 metres!

**EXERCISE**

**Complete the exercises for Lesson 4 in the Send-in exercises**

# Suggested answers

## Activity 1 – Drops of water (Page 10)

1. When you squeezed the water drop out of the dropper, did the water hold together or break apart?

   *The water held its shape for a while.*

2. When you were pulling the drop around the wax paper, did the water seem to hold together or come apart easily?

   *The water drop held together well.*

3. When you tried to split the drop, did the drop separate easily?

   *The drop was not easy to separate.*

4. Was it easy or difficult to make the drops come together?

   *It was very easy for the drops to come together.*

5. Water *does* hold together well

   Water *does not* hold together well.

## Activity 2 – Particles in motion? (Page 13)

1. Without being stirred the colour slowly mixed/ did not mix into the water.

2. Caption 1 :

   *Food colouring just added to the water*

   Caption 2

   *Food colouring was evenly spread throughout the water after 5 minutes.*

## Activity 3 – Explaining Brownian motion (Page 18)

Brown studied pollen under a microscope. He made a slide by putting the pollen in water. When looking at the pollen slide under a *microscope* Brown observed the pollen was *moving* continuously and randomly in jerky movements.

These observations can be explained by the theory that water is made of very small *particles* that are constantly moving. The moving particles *collide* with the pollen and push them around in all *directions*

## Activity 4 – Diffusion in hot and cold water (Page 23)

**Conclusion**
The rate of diffusion is faster in hot water than in cold water.

## Activity 5 - Particles in hot water and cold water (Page 25)

1. Heating a liquid *increases* the motion of particles.
2. Cooling a liquid *decreases* the motion of particles.
3. As the motion of particles increases, the space between the particles *increases*.
4. As the motion of particles deceases, the space between the particles *decreases.*

## Activity 6 – Observing the red liquid in a thermometer (Page 27)

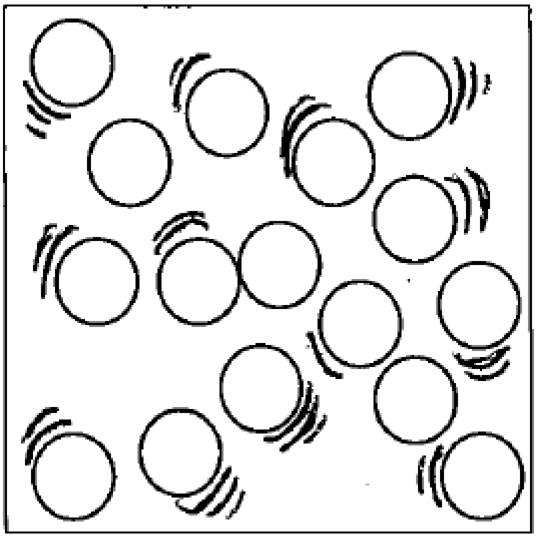
Results: The red liquid goes *up* in hot water and goes *down* in cold water.

## Activity 7 - Using the model of particles (Page 29)

One difference between the particles shown in the diagrams is the particles in cold water are closer together.

Another difference between the particles shown in the diagrams is the particles are moving more slowly.

In your diagram of hot water, the particles are further apart and there are more motion lines



## Activity 8 – Demonstrating a ball and ring (Page 35)

i. When the ball is heated the particles in the metal *vibrate* faster and they move *further* apart from each other.

ii. When the particles move further apart the ball has *expanded*.

It is now too *big* to fit through the ring.

b. Circle the phrases that describe what happens to the particles.

| | |
|---|---|
| get further apart | get closer together |
| vibration slows down | vibration speeds up |

# Send-in exercises – Modelling matter Part 1

## Lessons 1 and 2 – What is matter?

1. What is the scientific definition of matter?

_______________________________________________

_______________________________________________

2. Name the three states of matter that are normally found on Earth.

_______________________________________________

3. Water is one type of liquid. List two other substances that are in the liquid state at room temperature.

Example one _______________________________________

Example two _______________________________________

4.


Use the USB sent to you for the topic and watch the video *Water balloon* or go to the elearning site and view the video in the Video book for Modelling matter.

a. D
escribe what you observed immediately after the balloon was pierced.

_______________________________________________

_______________________________________________

b. What does this tell you about the particles in a liquid?

______________________________________________

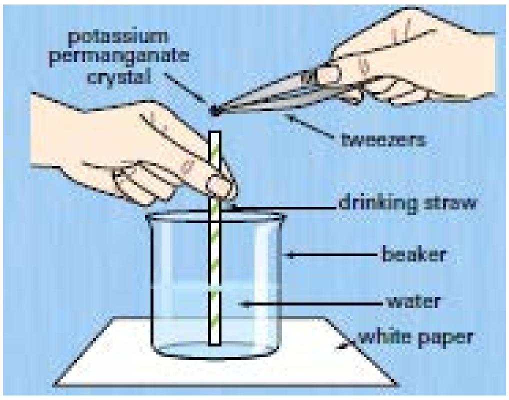
______________________________________________

5. A student was using a substance called potassium permanganate in an investigation to observe one of the effects of particles in a liquid.

Potassium permanganate is a dark purple substance. It stains a person's skin purple. The common name of potassium permanganate is Condies Crystals. Below is a close-up photograph.

Potassium permanganate

The student set up their investigation as shown in the diagram below.




a. Look at the diagram above. One important safety precaution that should be followed by all students when handling chemicals is not shown. What safety precaution is missing? (Hint: look at the hands.)

______________________________________________

b. The student photographed their results as shown below.

After I minute

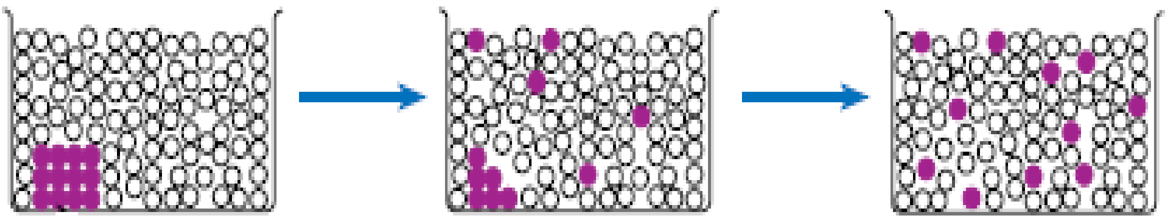
After 45 minutes

After 2 hours 30 minutes

When explaining the results of the experiment the teacher gave out the following diagrams.

Draw a line to connect the correct label to each of the diagrams. The labels are in the boxes below.

Diagrams:



Labels:

| | | |
|---|---|---|
| Potassium permanganate and water particles become evenly mixed because the particles are constantly moving. | The water particles are constantly moving. | Particles of potassium permanganate are slowly pushed around by the moving water particles. |

## Lesson 3 – Temperature and motion of particles

1. Describe what happens to water particles when they are heated.

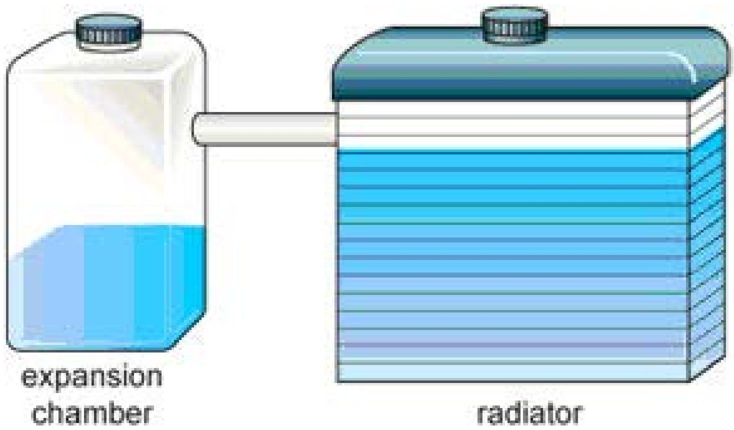
_______________________________________________

_______________________________________________

_______________________________________________

2. When a car is moving a lot of heat is produced. A car radiator contains water that is used to cool the engine.

   As shown below, an expansion chamber for the water is attached to the radiator in a car.




   Explain why an expansion chamber is necessary on a car radiator.

_______________________________________________

_______________________________________________

_______________________________________________

## Lesson 4 - Particles in a solid

1. Use the words in the wordbank below to complete the following sentences.

| | | | |
|---|---|---|---|
| expand | expansion | contract | contraction |

The particle model of matter can be used to explain the behaviour of solids and liquids.

For instance when a solid or a liquid is heated, the particles move faster and they take up more space. The substance will ________________.

When a solid or a liquid cools down, the particles will move slower and take up less space. The substance will ____________________.

When engineers design bridges the ______________________ and ______________________ of the railway tracks needs to be allowed for.

# Science
# Stage 4
## Modelling matter
## Part 2



Education & Communities
Distance Education Science Network

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# Contents

# Outcomes

By completing this part, you are working towards achieving the following outcomes:

- identify questions or problems that can be tested or researched and make predictions based on scientific understanding
- produce a plan to investigate identified questions, hypotheses or problems, individually and collaboratively
- follow a sequence of instructions to safely undertake first-hand investigations to collect valid and reliable data and information, individually and collaboratively
- process, analyse and evaluate data from first hand investigations and secondary sources to develop evidence based arguments and conclusions
- present science ideas and evidence for a particular purpose and to a specific audience using appropriate scientific language, conventions and representations
- describe the observed properties and behaviour of matter using scientific models and theories about the motion and arrangement of particles

The following are taken from the Board of Studies NSW Syllabus for the Australian Curriculum SCIENCE Years 7 - 10, 2013

Content Statements:
WS4a, WS4b, WS5.1a, WS5.1b, WS5.1c, WS5.2a, WS5.2c, WS5.2d, WS5.3a, WS5.3b, WS6a, WS6b, WS6c, WS6d, WS6e, WS7.1a, WS7.1b, WS7.1c, WS7.1d, WS7.1e, WS7.2a, WS7.2c, WS7.2d, WS7.2e,WS8e, WS9a, WS9b,WS9d, CW1a, CW1b, CW1c, CW1d, CW1e

# Resources

Here is a list of materials you will need to gather from home to use in Parts 1 and 2

**Part 1**

2 glasses
Ice cubes
2 plastic lids (from storage containers)
Cotton wool ball or tissue

**Part 2**

2 pegs
Wire coathanger
Plastic cup
Tissue
Large container (eg ice-cream container)
Square of thick cardboard (10 cm x 10 cm)
2 identical glasses
Kitchen scales

You will also be supplied with a mini-kit for Parts 1 and 2.

The modelling matter mini-kit contains the following items:

2 paddle pop sticks
Pipette
Blue, yellow and red coloured sugar crystals
Thermometer
2 balloons
2 metal cubes
USB with various videos

# Icons

Write a response or responses as part of an activity. An answer is provided so that you can check your progress.

Compare your response for an activity with the one in the suggested answers section.

Complete an exercise in the exercises section that will be returned to your teacher.

Think about information or ideas. You need to pause and reflect. You may need to make notes.

Perform a practical task or investigation.


Stop and consider the risks to safety for yourself and others.


Use the USB sent to you for the topic

# Glossary

Here is a list of the key terms used in this unit.

| | |
|---|---|
| **boiling point** | temperature at which a substance changes from a liquid to a gas |
| **change of state** | process by which matter changes from one state to another |
| **condensation** | the process where a gas changes state to a liquid |
| **contraction** | becoming smaller or decreasing in size or volume |
| **density** | measure of mass per volume of a substance |
| **diffusion** | process where one substance is thoroughly mixed in another |
| **evaporation** | the process where a liquid changes state to a gas |
| **expansion** | becoming larger or increasing in size or volume |
| **freezing point** | the temperature at which a liquid changes state to a solid |
| **heat** | a form of energy. Heat energy is released when a fuel burns |
| **mass** | the amount of matter in a substance. Mass is measured in grams, kilograms or tonnes |
| **melting point** | the temperature at which a solid changes state to a liquid |
| **prediction** | a forecast based on scientific understanding or observations |
| **solution** | a mixture in which one substance dissolves in another |
| **temperature** | a measure of how hot a substance is |
| **weight** | the force due to the action of gravity on the mass of a substance. In science it is measured in Newtons |

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# Lesson 1: Is air matter?

Remember last week that we investigated the particles in two states of matter - a liquid and a solid.

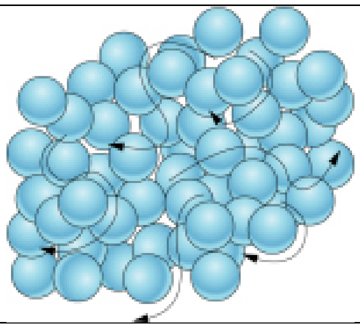
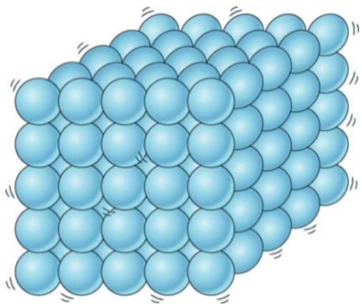
## Activity 1 - Comparing liquids and solids

Below is a table that compares the arrangement and behaviour of particles in liquids and solids. However it has not been completed. Following the table is a list of statements.

Read through the statements carefully then:

(a) underline the statements that describe liquids

(b) circle the statements that describe solids

| **Particles in states of matter** | |
|---|---|
| **Liquid** | **Solid** |
|  |  |
| Particles are attracted to each other. | Particles are very strongly attracted to each other. |

Particles are in constant motion but only backwards and forwards in their fixed positions.

Particles are close to each other but they can move past each other.

Particles are arranged in no particular pattern.

Particles are arranged in a fixed, definite pattern.

*Compare your answer with the one in the suggested answers section*

## Is air matter?

Air is all around us but we don't really detect it. We can't feel that it has weight and we can't see it. So is air matter?

Our definition of matter is that that it takes up space and has mass.

Following are two investigations to see if air is matter. Does air have mass and does air take up space?

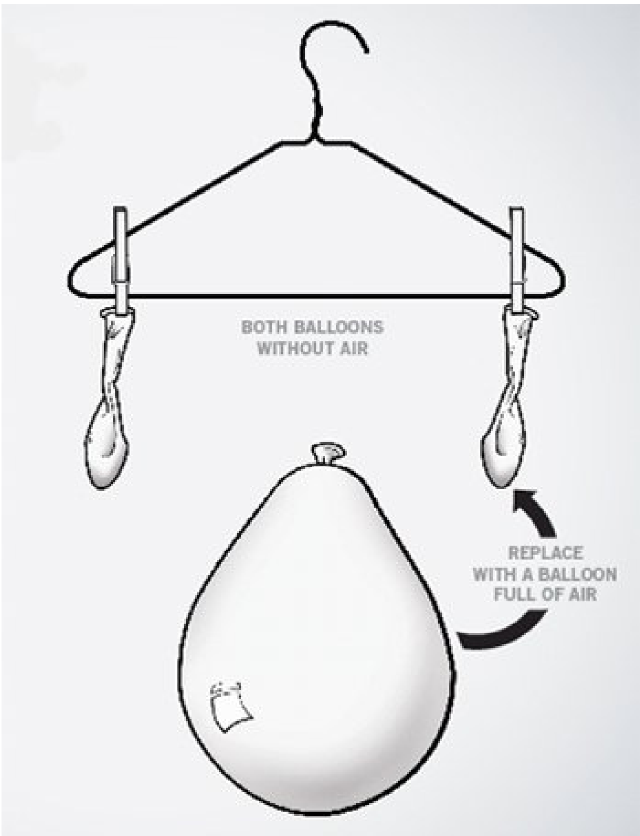
## Activity 2 - Air is matter

**Part A: Air has mass**

The aim for this investigation can be written as a simple statement:

To see if air has mass.

To see if air has mass, set up an investigation as illustrated below.



## Materials

You will need to collect the following:

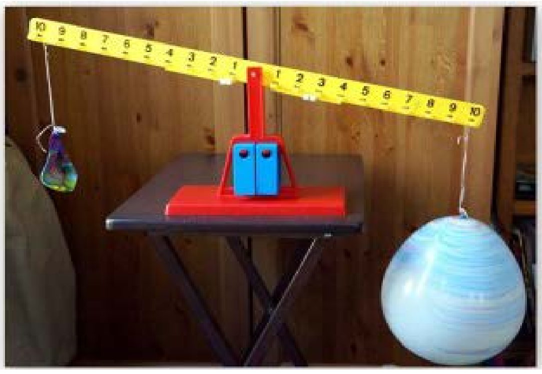
- Wire coat hanger
- 2 balloons
- 2 pegs

## Procedure

1. Find a place that is smooth to hang the coat hanger so that it swings freely (over a smooth metal door knob is a good place).
2. Use a peg to suspend each balloon from the coathanger. Move the position of the balloons until they are balanced and the coat hanger doesn’t swing.
3. While trying not to move the position of the peg, remove one balloon. Blow it up, tie it off and hang the balloon back on the peg.
4. Observe what happens.

## Expected results

The expected results are that the coat hanger is weighed down on the side with the inflated balloon. The coat hanger is like a seesaw. The heavier side goes down. The photographs below show a similar experiment set up with laboratory equipment.

i. Unscramble the phrases to construct a sentence about what you observed.

| | |
|---|---|
| When the inflated balloon | the coat hanger dipped down |
| was pegged back in position, | due to the mass of the air in the balloon. |

ii. Think about why the inflated balloon caused the wire hanger to dip down.

It shows that the inflated balloon has a greater mass than an uninflated balloon. Air was the only type of matter that was added to the balloon.

## Conclusion

A conclusion is written as a simple sentence that answers the aim.

To write your conclusion, circle the words that best complete the sentence about this investigation.

This investigation *shows/does not show* that air has mass.

*Compare your answer with the one in the suggested answers section.*

**Part B: Air takes up space**

**Aim:**

Write a simple sentence that is a suitable aim for this investigation. You can refer to the aim written for Part A to use as a guide.

_______________________________________________________________

*Compare your answer with the one in the suggested answers section.*

To complete this investigation you will need the following materials:

- one plastic cup
- one tissue or small serviette
- large pot or container

**Procedure**

1. Scrunch up the serviette or the tissue.
2. Jam the tissue in the bottom of the plastic cup.
3. Half fill the container with tap water.
4. Hold the plastic cup upside down by the bottom and push it down into the water.
5. Remove by lifting straight up and feel the tissue.

Hold the cup by the bottom and push the cup straight down

### Expected results

The expected result is that the tissue is dry.

This means there is something else besides the tissue in the cup. If the cup had nothing in it, then the water would fill the cup and wet the tissue.

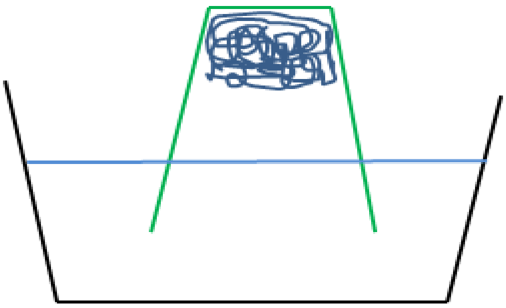
Air is in the cup and it is taking up space around the tissue.

The following diagram is unlabelled and incomplete.

i. Add a line to indicate the level the water rose to in the glass

ii. label the diagram with the following terms:

| | |
|---|---|
| water in the container | air in the cup |
| tissue | water in the cup |



*Compare your answer with the one in the suggested answers section.*

### Conclusion

Write a short sentence that answers the aim of this investigation. You can refer to the conclusion for Part A to use as a guide.

*Compare your answer with the one in the suggested answers section.*

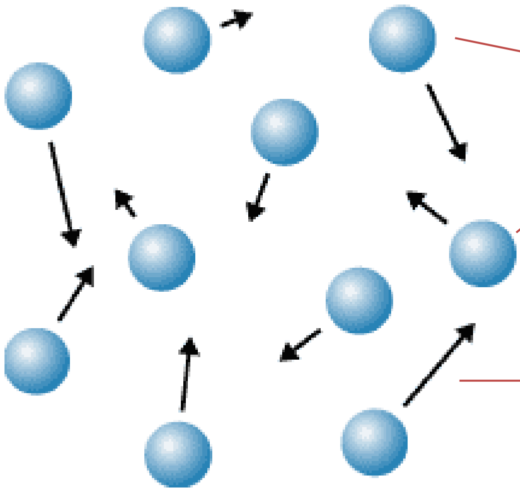
**Air takes up space and has mass, therefore air is matter.**

The last two investigations answered the question *is air matter?* Matter is made of incredibly small particles. How would the particles in air, or any gas be arranged?

## Particles in a gas

In a gas the particles:

- are randomly arranged
- move freely in all directions
- are not close to each other, in fact they are far apart
- have weak forces of attraction between them because they are far apart.

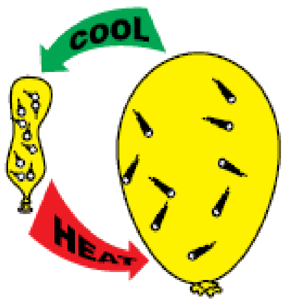


The particles in a gas are far apart

The black arrows represent the direction of motion. The particles move in all directions

**Explaining the behaviour of gases**

The particle theory can be used to explain why inflated balloons expand in the sun.




In the cool balloon the gas particles move slowly. When the balloon is placed in the sun, the air particles move more quickly. The faster moving particles hit the walls of the balloon more violently, pushing them out and causing the balloon to expand. You can try this activity to confirm that this happens.

Gases expand when they are heated, just as solids and liquids do. The particles in a gas move faster and take up more space. When gases are cooled they contract because the particles move more slowly and take up less space.

## Activity 3 – Diffusion in air

When a can of deodorant gas is sprayed in one corner of a room, a person standing on the other side of the room can quickly detect it.

The process where particles of different substances mix evenly together is called diffusion. The deodorant gas diffuses in the air.

Use your knowledge of the particle theory of a gas to outline how the deodorant gas moves throughout the air in the room.

The following words and phrases can be used to help you write your answer.

| | | |
|---|---|---|
| constantly moving | collide | push in all directions |
| The particles in air | spread throughout the space | |
| particles in deodorant gas | | |

__________________________________________________________

__________________________________________________________

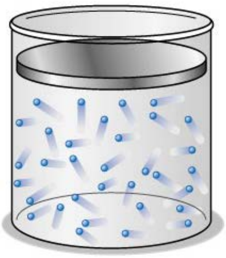
__________________________________________________________

*Compare your answer with the one in the suggested answers section.*

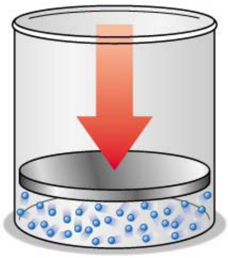
### Gases compress

The particles in a gas are very far apart. They can be pushed closer together or compressed.

Look at the diagram below which shows a gas being compressed.



(a)



(b)

There are the same number of particles in cylinder (a) and (b) but they have been pushed into a smaller volume in (b).

Neither liquids nor solids can be compressed. The particles in a liquid and solid are already very close together and they cannot be pushed any closer together.

## Summary

- Gases are made of particles that are constantly moving.
- In a gas the particles:
  - are very far apart
  - have very little attraction between each other
- Gases can:
  - expand
  - contract
  - diffuse
  - be compressed

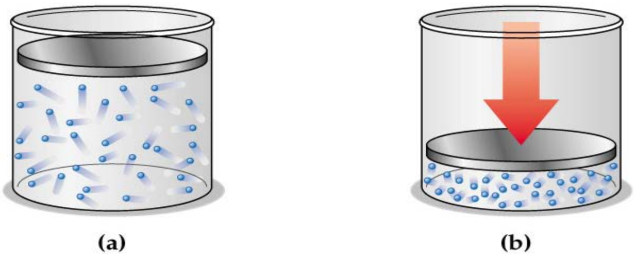
**EXERCISE**

**Complete the exercises for Lesson 1 in the Send-in exercises**

# Lessons 2 and 3: Density

Density is a property of matter. Density is a measure of how much matter is in a certain space. The more matter in a space, the greater the density. The space that matter takes up is called the volume.

Have a look at the diagram below from the last lesson. Which is denser – (a) or (b)?




The same number of particles is in each container so we can say there is the same mass in each container. However they do not take up the same amount of space. In (b) more mass is packed into a smaller volume so container (b) is more dense than container (a)

## Activity 4 – Densities of hot and cold water

The aim we will investigate is:

*To see if the temperature of water will affect its density.*

To complete this activity collect the following materials:

- cold water from the fridge
- hot tap water (no more than 50°C)
- 2 identical glasses, clear plastic cups or jars (baby food or salsa jars)
- Blue and yellow coloured sugar crystals
- square of thick cardboard (from a cereal box)

**Procedure**

A. Hot water on top

1. Completely fill one glass with hot tap water and add some yellow coloured sugar crystals using the paddlepop stick.
2. Completely fill the second glass with very cold water and the same amount of blue coloured sugar crystals. Stir the water in both glasses so that the coloured sugar has dissolved and the colour is well mixed. Place the cold water glass in the kitchen sink (to catch any spills).
3. Hold the cardboard over the top of the hot water glass (yellow).
4. While holding the card against the top of the glass, carefully turn the glass upside down.

5. With the cardboard still in place, position the glass of hot water (yellow) directly over the glass of cold water (blue) so that the tops line up exactly.
6. Very slowly and carefully remove the cardboard so that the hot water glass sits directly on top of the cold water glass.

**Expected results**

Although removing the card may result in a little mixing or spilling, the hot yellow water will remain in the top glass and the cold blue water will remain in the bottom glass.

Why do you think the hot water stayed on top of the cold water? Think about the particles in hot water compared to the particles in cold water.

In hot water the particles are further apart and they move faster compared to the particles in cold water.

So in a glass of hot water there are fewer particles than in an identical glass of cold water.

The hot water is less dense than the cold water and it ‘floats’ on the cold water.

In fact, any substance that is less dense than water will float.

Predict what would happen if the cold water was on top of the hot water.

*You can test your prediction by completing investigation as before but put the cold water glass over the hot water glass.*

**Conclusion**

Write a conclusion for the experiment to see if the temperature of water affects its density.

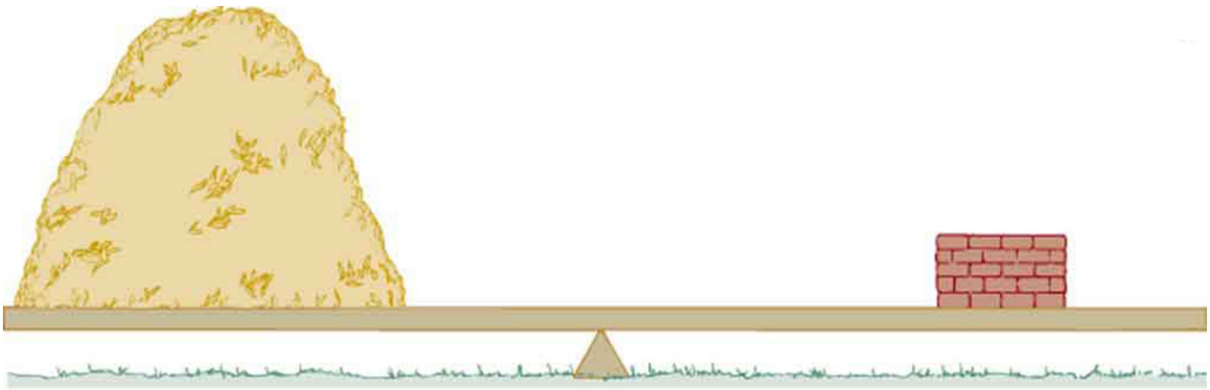
*Compare your answer with the one in the suggested answers section.*

## Densities of different substances

So far we have looked at different densities of the same type of matter, air and water.

What about the densities of different substances?

For instance, what is the difference between one kilogram of bricks and one kilogram of feathers?



The difference is that the mass of the bricks is packed into a much smaller volume then the mass of the feathers.

The bricks are more dense than feathers.

The particles in bricks are different to the particles in feathers. In a brick, each particle may be heavier than a particle in a feather. Also, the particles in a brick might be packed more closely together so that there is more mass compared to a feather.

Density is how much mass is packed into a measured volume. Mass is measured in grams, symbol **g**. Volume is measured in centimetres cubed, symbol **$cm^3$**.

The density of water is $1 g/cm^3$. This means there is one gram of mass in each one $cm^3$ of water. Compare this to gold which has a density of $19 g/cm^3$. This means there is 19 grams of mass in every one $cm^3$ of gold. Gold is denser than water.

Will gold float or sink in water? An object will float in water if it has a density equal to or lower than water. The density of gold is higher than water and so gold sinks.

So why do we float?

We float because we are mostly water. As well there is a layer of fat just under our skin. Fat is less dense than water. There are also air spaces, such as lungs, inside our bodies.

Substances will float in other liquids, not only water. The rule is a substance will float in a liquid if it has a density equal to or lower than the liquid

This is a picture of a density column. It is made by carefully pouring in liquids in order of their decreasing densities. Some of the liquids, such as the water, have food colouring added to make them easier to see.

The objects are dropped in last.

Steve Spangler made this density column. He is a scientist who has some great experiments on his website.


## Activity 5 – A density column

Look carefully at the picture of the density column above and answer the following questions.

1. Underline the words that correctly complete the sentence.

   A substance will float in or on a liquid if it has a density *equal to or lower than/more than* the liquid.

2. In the picture above locate the position of water.

   a. Name one liquid that is less dense then water _______________

   b. Name one solid that is more dense than water _______________

   c. Name the most dense liquid _______________________________

*Compare your answer with the one in the suggested answers section.*

## Mass and weight – what's the difference?

In our everyday life the terms mass and weight mean much the same thing. We use scales to make a measurement.

However in science, mass and weight have different meanings.

In science, *mass* is the amount of matter in a substance. We measure mass in grams (g) or kilograms (kg).

Weight is a *force*. In science weight is measured in Newtons, symbol N. Weight is the force due to gravity on an object.

The difference between mass and weight is more obvious when you think about an astronaut.

In space an astronaut has no weight because there is no gravity but their mass is the same as it was on Earth.

If the astronaut walks on the Moon, their weight is less than it is on Earth because the force of gravity on the moon is less than it is on Earth. However their mass is the same.

## Activity 6 - Calculating density

The formula for calculating the density of an object is:

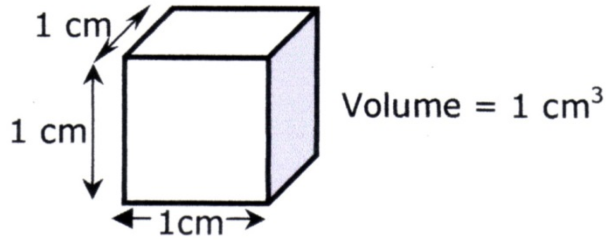
$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

To calculate the density of an object we need two measurements - its mass and its volume.

Measuring mass is easy with a set of scales. Finding the volume is easy with a regular shape, like a cube.

Take a 1cm cube.

Volume = length x breadth x height




Below are two worked examples.

1. Find the density of a 1 cm cube of wood that has a mass of 0.3g.

   Density $= \dfrac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$

   $= \dfrac{0.3}{1}$

   $= 0.3\text{g/cm}^3$

2. Find the density of a 2cm cube of glass that has a mass of 16.0g

   Mass = 16.0g, volume = 2 x 2 x 2 = 8cm$^3$

   Density $= \dfrac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$

   $= \dfrac{16}{8}$

   $= 2\text{g/cm}^3$

Work out the answers for questions 3 and 4

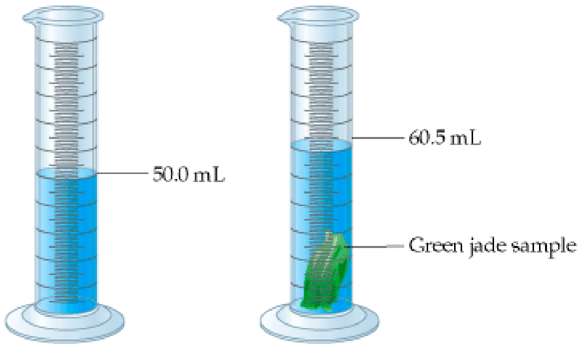
3. Find the density of a 2cm cube of foam that has a mass of 0.40g

4. Find the density of a 3cm cube of glass that has a mass of 54.0g

*Compare your answer with the one in the suggested answers section.*

## Finding the volume of irregular shaped objects

If an object is irregular or oddly shaped, it can be weighed to find its mass but finding the volume is more difficult.




Its volume can be found by placing the object in a measuring cylinder and measuring how far the water rises. This works because 1 millilitre (mL) of water takes up the same space as $1cm^3$.

Before the green jade was added to the measuring cylinder, the volume of water was 50.0 millilitres (50mL)

After the jade was added the water level rose to 60.5 millilitres (60.5mL)

The volume of the green jade is equal to the difference between the final volume and the initial volume.

Volume = final volume – initial volume

= 60.5 – 50.0

= $10.5\ cm^3$

The piece of jade weighed 31.5g. This is the mass.

We can now calculate the density of this piece of jade.

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

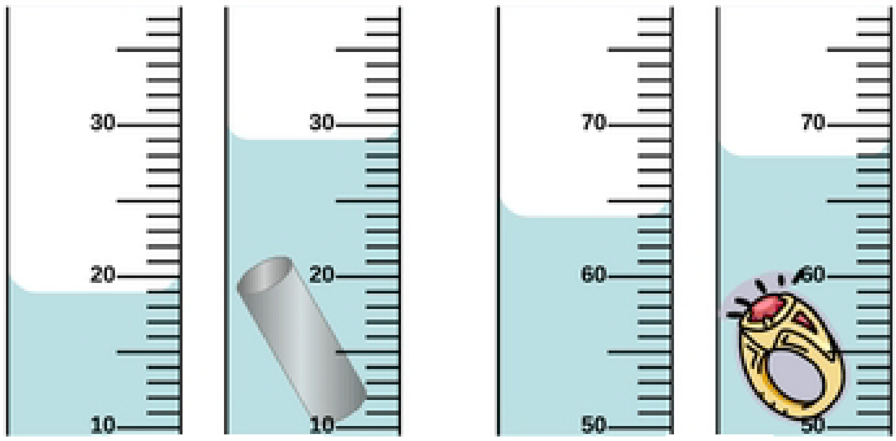
$$= \frac{31.5g}{10.5cm^3}$$

$$= 3.0/cm^3$$

The density of this piece of jade is $3.0g/cm^3$.

## Activity 7 – Finding the volume of irregular shaped objects

Below are diagrams showing the difference in volume of water when two different objects are placed in a measuring cylinder.




Metal cylinder ring

In the above diagrams, the water rises up the glass sides of the measuring cylinder. This is due to the attraction of the water particles to the glass. The resulting shape is called a meniscus. When you measure the volume of water in a measuring cylinder, you read the horizontal level of water. Have your eye at the same level as the water to take these readings.

Calculate the volume of:

| 1. the metal cylinder | 2. the ring |
|---|---|
| | |

*Compare your answer with the one in the suggested answers section.*

## Summary

- Density is a property of matter.
- Each substance has its own particular density.
- Density is a measure of how much mass is in a measured volume.

  $$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3)}$$

- Substances with a lower density will float on liquids with higher density.
- Mass and weight do not mean the same thing in Science. Weight is a force due to gravity acting on the mass of an object.

**EXERCISE**

**Complete Lessons 2 and 3 in the Send-in exercises**

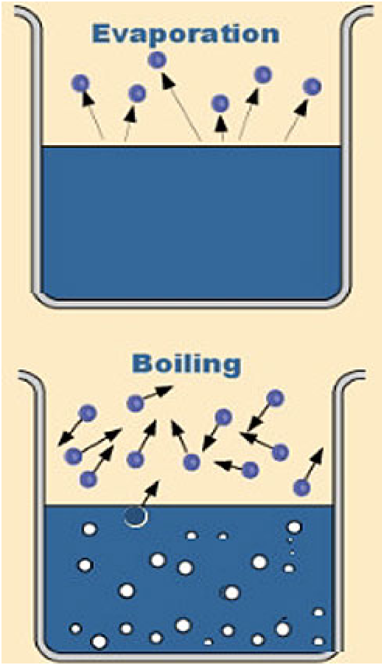
# Lesson 4 - Changing state

The three states of matter can be changed from one state to another by adding or removing heat. These changes are called changes of state.

**Evaporation**

Evaporation occurs when the particles in a liquid gain enough heat that they overcome attractions from other particles and break away to become a gas.

This happens at the surface of a liquid. This is why a dish of water will eventually ’disappear’. The liquid water has changed into a gas called water vapour.




Adding heat increases the rate of evaporation. The particles move faster and more of them can break away from the surface.

For instance, the hotter water gets, the more quickly it evaporates. When bubbles start to appear in the water it is *boiling.* The bubbles are a gas called water vapour or steam.

The temperature at which a particular liquid boils is called its boiling point. The boiling point of water is 100$^{O}$C. Each liquid has its own boiling point as shown in the table below.

| **Substance** | **Boiling point ($^{O}$C)** |
|---|---|
| Water | 100 |
| Olive oil | 300 |
| Candle wax | 400 |
| Table salt | 1465 |
| Gold | 2856 |

## Activity 8 – Condensation

Condensation is the reverse of evaporation. Condensation is the process in which particles of a gas slow down, come together and form a liquid.

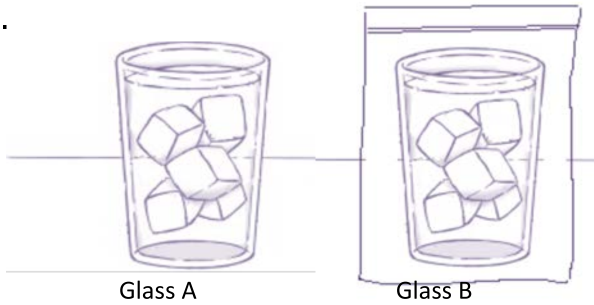
Below is a diagram of a demonstration of the process of condensation.

Iced water is added to two clear glasses.

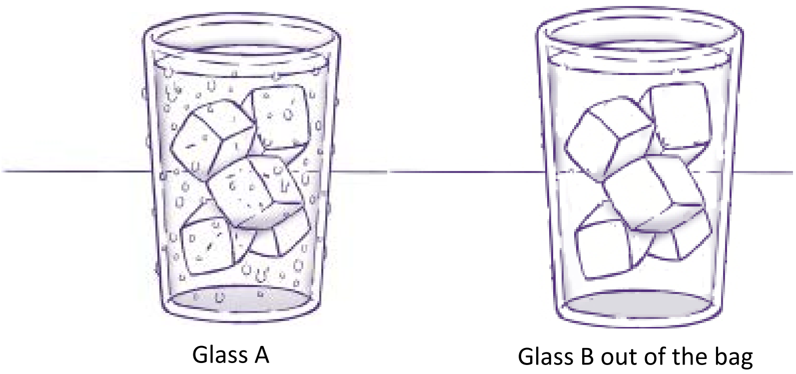
Glass B is placed in a zip-lock bag.

The air is removed from the bag before it is sealed.

The glasses are left for 10 minutes.




Below is a diagram of Glass A and Glass B after 10 minutes.




1. State one difference between the outside of the glasses that has been observed.

   ______________________________________________________

2. Complete the following sentences using the words below.

| | | | |
|---|---|---|---|
| droplets | changed state | condensation | |
| no | removed | air | leaking |

The outside of Glass A has __________ of liquid water. The droplets have formed due to the process of c________________. Water vapour in the air has ____________________ ______________ from a gas to a liquid.

The outside of Glass B has ___ big droplets of water. This is because the air containing the water vapour was r___________ from the zip-lock bag.

This demonstration shows that the water droplets come from the surrounding _____ and not from the water ______________ through the glass.

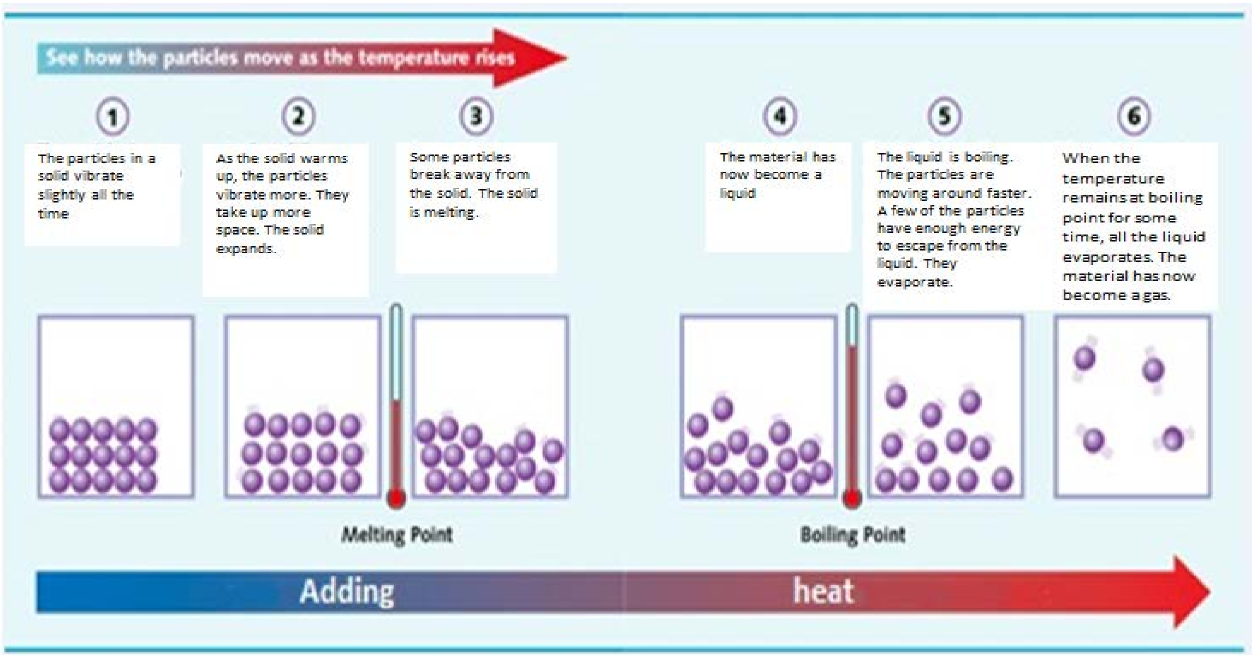
*Compare your answer with the one in the suggested answers section.*

An example of condensation of water vapour is fogging up a cold window. When you breathe on a cold window in winter, the window gets tiny droplets of water on it, it fogs up. This happens because there is water vapour in your breath. The particles of gas slow down when heat is removed by the cold window. The attractions between the slower moving particles of water vapour bring them together to form tiny droplets of liquid water.

**Melting**

Melting is a change of state from a solid to a liquid. Melting occurs when heat is added which makes the particles in the solid vibrate more. With enough heat, the particles move more vigorously and the force of attraction between the particles is lessened and they lose their fixed pattern. A liquid is formed. The temperature at which a solid melts is called its melting point. The melting point of water is 0 °C.

The diagram below shows changes of state from a solid to liquid to gas by adding heat. Adding heat increases the temperature.



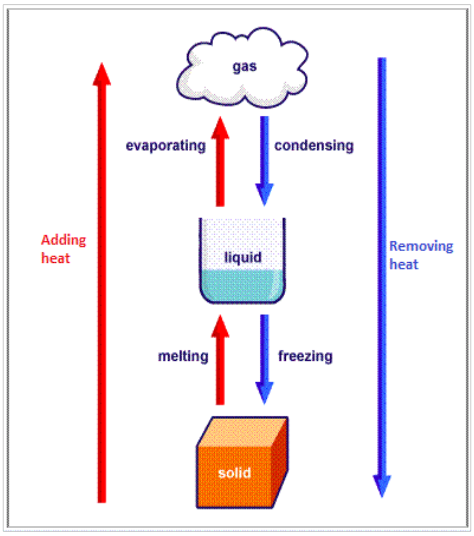

## Freezing

Freezing is the process that causes a substance to change from a liquid to a solid. Freezing is the reverse of melting, so the freezing point and melting point are the same temperature.

Freezing occurs when heat is removed. The particles slow down enough so that attractions between the particles cause them to arrange themselves into fixed positions as a solid.

The diagram shows the connection between all the processes which occur when a substance changes state.

Use this diagram to answer the questions in Activity 9.



## Activity 9 - Condensation

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Refer to the previous diagram to assist you in answering the following questions.

1. Choose one of the following words to say what type of substance will be formed in each situation.

| | | |
|---|---|---|
| solid | liquid | gas |

   a. a gas condenses ______________________________

   b. a liquid freezes ______________________________

   c. a solid melts ______________________________

   d. a liquid boils ______________________________

2. The table below lists 5 changes of state. For each change, decide whether adding heat or removing heat is needed. Place a tick in the appropriate column.

| **Change of state** | **Heat added** | **Heat removed** |
|---|---|---|
| Solid to liquid | | |
| Liquid to gas | | |
| Gas to liquid | | |
| Liquid to solid | | |

*Compare your answer with the one in the suggested answers section.*

## Freezing water

Have you ever left a full bottle of water in the freezer for too long so that when you go to get it out the ice has forced its way out of the bottle? If the bottle is glass it may have even broken.

When water freezes it expands.

If you placed 10mL of water in a measuring cylinder and froze it, the ice formed would measure 11mL.

How does this affect density if the same mass is in a larger volume?

Remember the formula for calculating density is

$$\text{Density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}$$

The mass of 10 mL of water is 10g, the volume when it is frozen is 11cm$^3$.

$$\text{Density} = \frac{10\text{(g)}}{11\text{(cm}^3\text{)}}$$

$$= 0.9\text{g/ cm}^3$$

The density of liquid water is 1 g/cm$^3$. Ice is less dense than liquid water so ice will float on water.

Icebergs float on the oceans. The cruise ship, Titanic, was sunk after it collided with an iceberg.


Ice will float on top of rivers and lakes. People need to take care they don’t fall through the ice into the freezing water below the ice.

## Plasma – a fourth state of matter

Plasma is a fourth state of matter, but it rarely occurs on Earth. On earth the states of matter that we come into contact with are solids, liquids and gases.

Plasma is made of charged particles that are spread very, very far apart. Our Sun is made of plasmas, as are all other stars.

Lightning is a type of plasma and plasmas occur in neon signs and fluorescent tubes.

You may have seen a plasma ball similar to the one pictured. Scientists are experimenting with plasmas to try and produce energy in the same way that the sun does.

## Summary

- The three states of matter can be changed from one to another by adding or removing heat.
- Evaporation – a liquid changes to a gas
- Condensation – a gas changes to a liquid
- Melting – a solid changes to a liquid
- Freezing - a liquid changes to a solid
- Each substance has its own melting point and boiling point.
- Water boils at $100^{O}C$ and freezes at $0^{O}C$.

**EXERCISE**

**Complete the exercises for Lesson 4 in the Send-in exercises**

# Send-in exercises – Modelling matter Part 2

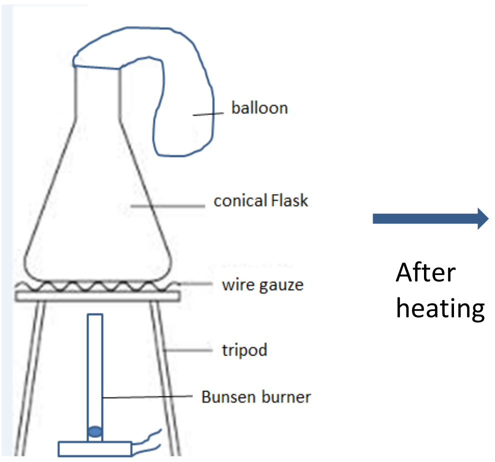
## Lesson 1 - Air is matter

1. Compare the properties of a gas to liquids and solids by completing the table below.

| **Property** | **Solid** | **Liquid** | **Gas** |
|---|---|---|---|
| Shape | Definite | Not definite | |
| Ease of compression | Very low | Very low | |
| Bonds between particles | Strong | Quite weak | |
| Movement of particles | Minimal | medium | |

2. A student set up an investigation as shown below. The air in the conical flask was heated for 1 minute.

   Draw a diagram in the box below showing what would happen to the balloon on the conical flask after 1 minute of heating.




Write a caption that describes what your illustration shows.

______________________________________________________________________

______________________________________________________________________

## Lessons 2 and 3 – Density

1. Examine the two metal cubes in your minikit. Make some qualitative observations.

    a. How the cubes similar?

    ______________________________________________

    b. How are the cubes different?

    ______________________________________________

2. Now make some quantitative observations by making measurements.

    a. Use a ruler to measure the length of each cube.

    Each cube is _________ cm in length

    *(hint – both cubes should be the same dimensions)*

    b. Calculate the volume of each cube.

    Volume = length x breadth x height

    ______________________________________________

    ______________________________________________

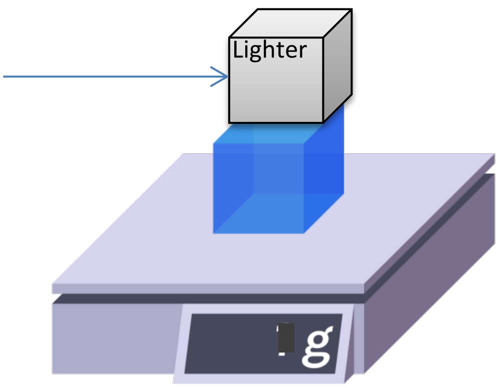
3. a. You will need kitchen scales to measure the mass of each cube.

    Record your measurements in the following table.

    i. Measure the weight of both cubes. Put the lighter one on top.

    ii. Record the combined weight.

    iii. Remove the lightest cube and record the measurement of the single heavier cube.



b. Complete the table by calculating the mass of each cube.

Calculating mass of the two cubes

i. Mass of both cubes = __________

ii. Mass of heavier cube = ________

Mass of lighter cube = Mass of both cubes – mass of heavier cube

= ________________________________________

= ________________________________________

4. Calculate the density of each cube. Show all of your working.

| Calculating density | | |
|---|---|---|
| | Lighter cube | Heavier cube |
| Mass | | |
| Volume | | |
| Density (Mass ÷ volume) | | |

5. Below is a list of the densities of common substances in $g/cm^3$.

Circle the two which are closest to the density you have calculated.

| | |
|---|---|
| Aluminium | 2.7 |
| Granite | 2.7 |
| Iron | 7.8 |
| Nickel | 8.9 |
| Lead | 11.3 |
| Gold | 19.3 |

6. Would these cubes float or sink in water? Give reasons for your answer.

________________________________________________________________

________________________________________________________________

## Lesson 4 – Changing state

1. Label the diagram with the *name of the process* for each change of state.