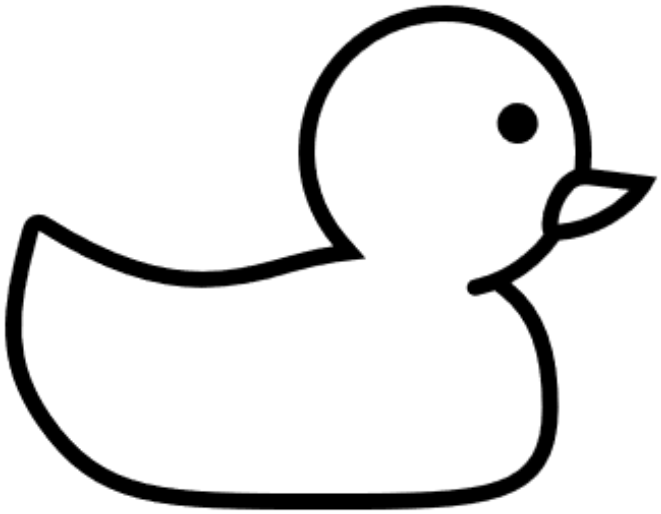
Floating and Sinking

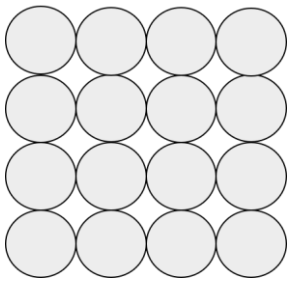


Particle model

All matter is made of particles. Depending on the substance, the particles could be atoms or molecules.

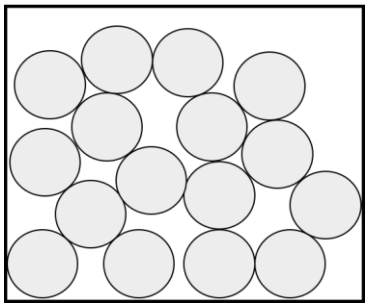
The three states of matter are solid, liquid, and gas. They all have different properties due to the arrangement and movement of their particles.

Solid



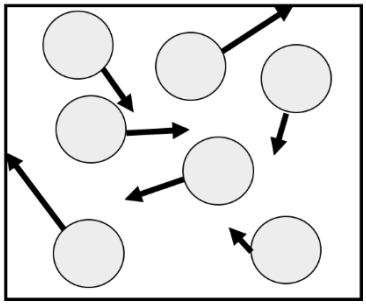
Solids have particles that are held tightly together. The particles are arranged in a regular pattern and vibrate around fixed positions. Solids have a definite shape and volume. Solids are dense and they cannot be compressed easily because the particles are already packed closely together. Solids have the least amount of energy.

Liquid



In a liquid the particles are still held closely together but the particles can also move past each other. This means that a liquid can flow. Liquids are dense and cannot be compressed easily (hydraulics make use of this). A liquid can change its shape but not its volume.

Gas



There are only very weak forces between gas particles, which are far apart. Because of this. gases can be compressed, and so they have no fixed volume. The particles move around quickly, at a range of speeds. They cause pressure when they collide with the walls of a container. Gases have a low density and they do not have a definite shape or volume. Gases have the most energy. As you heat a gas, the particles move more quickly.

While solids are usually the densest state of matter; water and ice are an exception. Water (a liquid) is denser than ice (a solid). That's why ice cubes float in a drink.

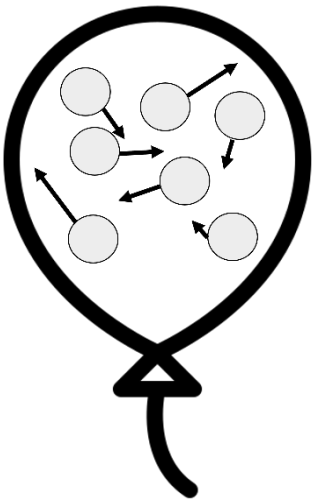
Pressure in gases

Gases consist of particles that move in random directions and at a range of different speeds.

We know this because of something called Brownian motion. In 1827, Robert Brown (which Brownian motion is named after) noticed that pollen particles moved around in a random way. Smoke particles move in a similar way in air. This is because of collisions with air particles that are moving in random directions and at a range of different speeds.

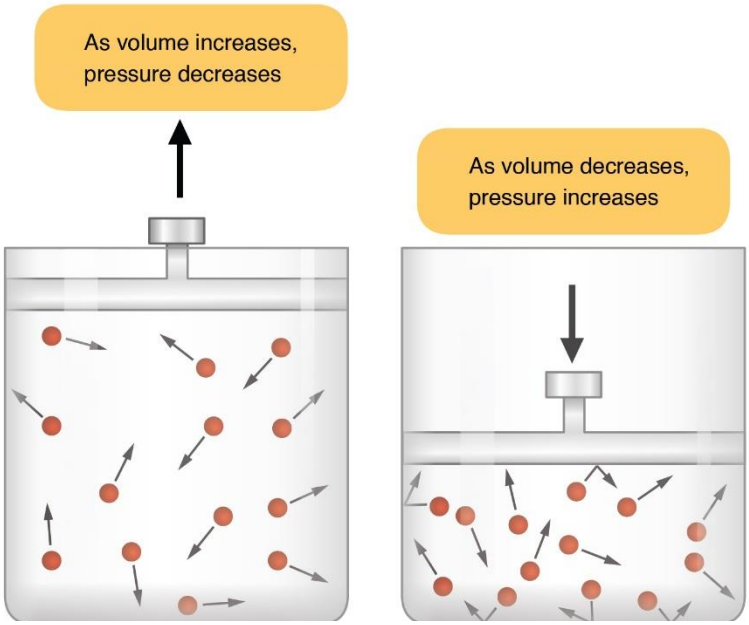
While the smoke particles are much larger than the air particles, the air particles are moving much faster and so they affect how the smoke particles move when they collide.

When a gas particle collides with a surface, pressure is exerted on that surface.



The reason balloons get bigger when you blow them up is because you are adding air into the balloon.

More air means more particles inside the balloon. In turn, this leads to more collisions between air particles and the walls of the balloon. More collisions cause a higher force on the walls, which then leads to a higher pressure. This makes the balloon expand.



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If we reduce the volume of a container, a similar thing happens. This is shown in the diagram to the left.

If the volume of a container is reduced, gas particles collide with the walls of the container more often.

This leads to a higher force on the walls of the container, and therefore a higher pressure.

If we increase the temperature of a gas in a container, the kinetic energy and speed of the gas particles also increase. This also means the gas particles collide with the walls of the container more often (again leading to a higher force and a higher pressure on the walls of the container). Therefore a balloon expands if we heat it.

Q1. Smoke particles are observed to move in a random way in air. State the name of this process and explain why this happens.

Q2. Air is being pumped into a balloon.

a) State what happens to the number of air particles inside the balloon.
b) State what happens to the number of collisions between the air particles and the walls of the balloon.
c) State what happens to the force exerted by the air particles on the walls of the balloon.
d) State what happens to the pressure inside the balloon.
e) State what happens to the size of the balloon.

Q3. Some gas is inside a container. The volume of the container is slowly increased.

a) State what happens to the force exerted by the air particles on the walls of the container.
b) State what happens to the pressure inside the container.

Q4. State what happens to the average speed of gas particles as the temperature of the gas is increased.

Q5. Two containers have the same amount of gas particles inside them. Container A is smaller than container B. State and explain which container has the highest pressure.

Q6. Two containers have the same amount of gas particles inside them. Container A is at a lower temperature than container B. State and explain which container has the highest pressure.

Q7. A balloon is cooled. State and explain what happens to the size of the balloon.

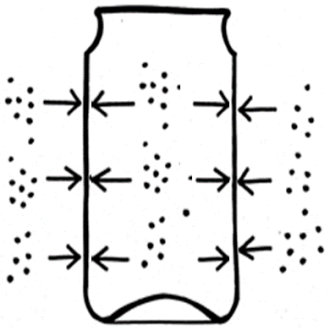
Gas Pressure – Crushing can demonstration

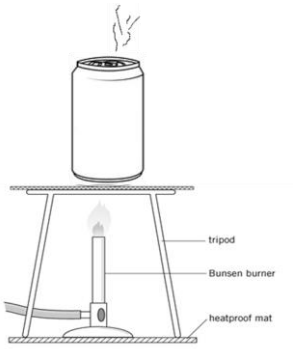
Use the words above each picture to explain that part of the experiment.

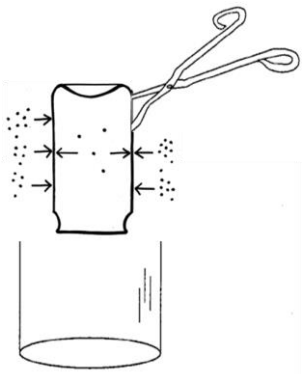
Pressure
Outside
Inside
Equal
Can

Heating
Increase/decrease
Pressure
Walls of the can

Cold water
Water vapour
Condense
Decrease
Pressure
Walls of the can
surroundings
implosion







Q1.

Sue pumps up a bicycle tyre. As she does so, she notices that the pump becomes hot.

(a) Where, and how, was the energy stored before it was transferred in pumping up the tyre?

1 mark

(b) Explain how the gas molecules inside the tyre exert pressure on the walls of the tyre.

1 mark

(c) The air going into the tyre was warmed up by the pumping. What effect will this have on the motion of gas molecules in the air in the tyre?

1 mark

(d) When the air in the tyre becomes hotter, the pressure rises. Give **one** reason, in terms of the motion of gas molecules in air, why the pressure rises.

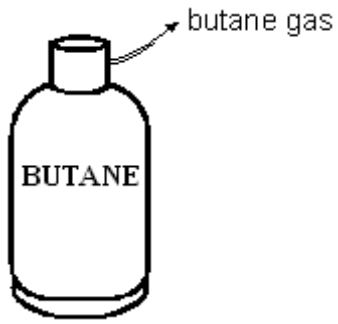
1 mark

(e) The pressure in the tyre increases as Sue forces more air into the tyre. Explain why a larger number of gas molecules increases the pressure in the tyre.

1 mark

Q2.

The drawing shows a cylinder of butane. The butane is under pressure in the cylinder. Most of the butane in the cylinder is liquid, but some is a gas.



(a) Choose which **two** statements about the molecules of butane gas in the cylinder are correct.

The molecules of gas are:

1. closer together than those in the liquid;
2. further apart than those in the liquid;
3. the same distance apart as those in the liquid;
4. bigger than those in the liquid;
5. smaller than those in the liquid;
6. the same size as those in the liquid;

2 marks

(b) The gas molecules exert a pressure on the inside of the cylinder.
How do the moving molecules cause this pressure?

1 mark

(c) (i) Explain why the pressure inside the cylinder falls when the temperature falls.

2 marks

(ii) Butane from the cylinder was used in a camping stove. If there was a large fall in the air temperature around the cylinder, what effect would this have on the flame of the camping stove?

1 mark

Mark schemes

Q1.

(a) as chemical energy in Sue **or** her muscles

__both__ parts are required for the mark
accept 'as chemical energy in glucose
***or** named chemicals'*

1 (L6)

(b) the molecules collide with the walls of the tyre

*accept 'they hit the walls **or** the tyre'*
***or** 'they bounce off the walls'*

1 (L7)

(c) they speed up **or** get faster

1 (L7)

(d) any **one** from

- they will hit the tyre wall more frequently
- they hit the tyre wall harder **or** faster

accept 'more collisions with the tyre'
*do **not** accept 'more collisions'*
*do **not** accept 'the molecules move faster'*

1 (L7)

(e) there will be more frequent collisions with the tyre wall

accept 'more collisions with the tyre'
*do **not** accept 'more collisions'*
accept 'the force applied by the molecules increases'
*do **not** accept 'less space for the molecules'*
*do **not** accept 'there are more air molecules to hit the tyre wall'*

1 (L7)

[5]

Q2.

(a) further apart than those in the liquid ✓

1 (L7)

the same size as those in the liquid ✓

1 (L7)

if more than two boxes are ticked, deduct
one mark for each incorrectly ticked box
minimum mark zero

(b) by hitting **or** colliding with the inside of the cylinder

1 (L7)

(c) (i) particles move more slowly **or** have less energy

accept 'some of the particles condense into a liquid'
*do **not** accept 'particles move less **or** vibrate more slowly'*

1 (L7)

particles hit the inside of the cylinder less hard **or** less often

*do **not** accept 'do not press so hard'*

1 (L7)

(ii) lower **or** smaller **or** less hot

*accept 'dies out' or 'drops' **or** 'less strong' **or** 'goes out'*

1 (L7)

Pressure in Liquids

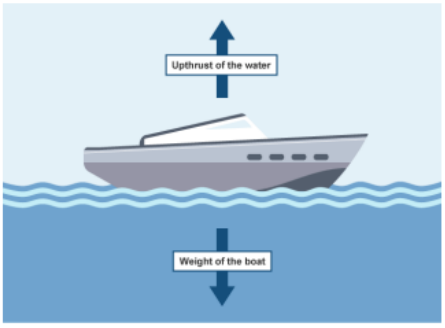
[6]

Pressure in liquids Just like the atmosphere, liquids exert pressure on objects. The pressure in liquids changes with depth.

The deeper you go:
- the greater the weight of liquid above
- the greater the liquid pressure

Pressure in a liquid increases with depth so the jet coming from the bottom of the bucket travels further sideways

Liquid pressure is exerted on the surface of an object in a liquid. This pressure causes upthrust. An object placed in a liquid will begin to sink. As it sinks, the liquid pressure on it increases and so the upthrust increases. For a floating object, the upthrust is equal and opposite to the object's weight. An object will continue to sink if its weight is greater than the maximum upthrust.



The weight of the boat is balanced by the upthrust from the water.

<u>What causes water pressure?</u>
Water will naturally flow downhill. A reservoir holds a lot of water and is usually quite high up. The weight of water in the reservoir provides the pressure to force water through pipes lower down.

Water pressure is bigger if there is a greater height of water feeding the pipes below. You can demonstrate this by making three holes in a plastic bottle, one above the other, and then filling the bottle with water. The water will flow fastest out of the lowest hole because there is more weight of water above it.
Water pressure can be also created by pumps where water is needed to be pushed to places that are higher up.

Why does water flow through pipes?

Water pressure pushes water through any available hole. If you puncture a balloon several times and fill it with water you will see it coming out of all the holes in every direction.

Pipes are like holes for water to flow through. The pressure pushes water along the pipes even when they bend. We can use pipes to direct the water to a specific place. The pressure needs to be sufficient to make water flow quickly through the pipes but not too much because it can make the pipes come apart.

Why is knowledge of water pressure useful?

Understanding water pressure is important for plumbers who need to make sure that water can flow properly through all of the pipes.

High water pressure is used by dentists to clean teeth, and it is also used by people at home using pressure washers to clean cars and driveways.

How to weigh a floating object without scales:

• When objects float on water the force keeping the object afloat is called upthrust and this balances the weight of the object.

• When something is placed in the water, the water that moves out of the way. We say the object is displaced.

• For floating objects the weight of displaced water is equal to the weight of the object.

What is upthrust?

- When objects float, they push water out of the way. We say the water is displaced.
- The water pushes back with a force we call upthrust.
- The water continues to be pushed out of the way until the upthrust equals the weight of the object.

Using upthrust to find the weight of an object:

- If the water that is displaced is weighed, we find it has the same weight as the object that is floating.

How does water pressure work?

- As the water comes out of the holes, the water level drops, meaning the jets of water from all of the holes slow down.
- Air pressure works in a similar way. The air pressure where you are, is determined by the weight of the atmosphere above you.
- If you climb a tall mountain, the air pressure decreases because there is less air above you.

Who needs to know about water pressure?

- Divers need to be aware of pressure in water. If you dive to the bottom of a swimming pool, your ears may start to hurt. This is due to the extra pressure around you. Deep sea divers train themselves to go many times deeper and need to know how to cope with this extra pressure.

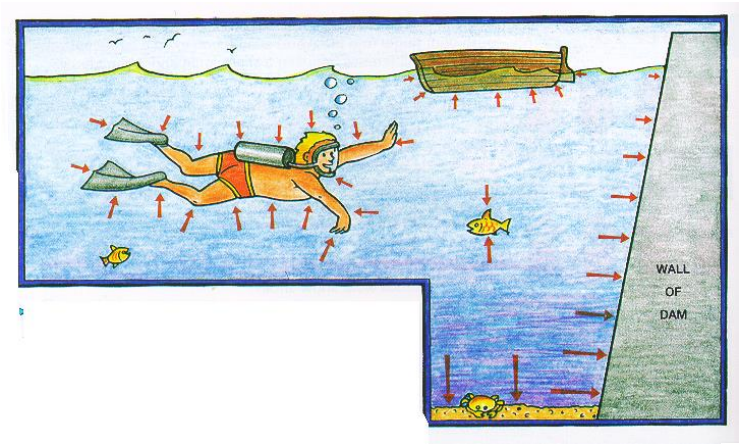
- Submarines can go very deep. They must be designed carefully to handle the enormous water pressure at those depths. At the bottom of the ocean the pressure is equivalent to an elephant standing on your finger, so submarines have to be very strong indeed!

Independent practice

1. Water pressure _____ on the bottom of the boat floating in water. Water inside a container presses on the walls in _____. A dam needs a thicker base because water pressure is _____ at the bottom of the lake. The pressure _____ depend on the shape of the container. The pressure _____ if a denser liquid is used. The weight of water above you _____ if you dive deeper. This means water pressure _____ as you dive deeper.

Keywords: *all directions, decreases, higher, increases, does not, decreases, pushes up, decreases, pushes down, increases, does, increases, no direction, lower.*

2. Describe what is causing pressure on the diver.
3. Why does the dam wall need to be thicker at its base?
4. Why does the boat float?
5. CHALLENGE: Why must the diver breathe out as he surfaces?



6.

Piñata Popping!

The animal with the highest pressure wins!

REMEMBER:
Pressure = force ÷ area
Unit = N/cm^3

 Colin Force = 30 N Area = 5 cm^3 Pressure	 Paula Force = 20 N Area = 10 cm^3 Pressure
 Ed Force = 100 N Area = 20 cm^3 Pressure	 Zak Force = 50 N Area = 5 cm^3 Pressure
 Gary Force = 63 N Area = 7 cm^3 Pressure	 Martin Force = 40 N Area = 8 cm^3 Pressure

EXPERIMENT - PRESSURE IN LIQUIDS

Setting the scene

In this activity you will find out about floating and sinking and how they are affected by density. You will also learn how pressure in water changes with depth.

Aims

In this activity you will:

- state that liquid pressure acts in all directions and increases with depth
- describe some objects that float or sink and explain why they float or sink.

You will be **working scientifically** to:

- predict how water pressure changes.

Task

Experiment - Floating and sinking

For each of the four objects shown, predict whether it will float or sink.

Fill the final column in as you observe the demonstrations.

Object	Predict – will it float or sink?	Did it float or sink?

DEMO - Water pressure in a bottle

1 State how water pressure changes as water depth increases.

_____

_____

2 Use your answer to Question 1 to predict the path of water through each hole in the bottle. Explain your answer.

Questions

1 Describe a pattern in your results of whether something will float or sink.

2 Explain why some objects floated and some sank.

3 Describe your observations of the water-pressure experiment. State whether your prediction was correct. Explain your observations.

CHALLENGE

1 Draw a force diagram to show a floating object in the space below. Draw only the two relevant forces in the vertical direction.

2 Compare the water pressure coming out of different parts of the bottle. Use the words **force** and **weight** in your answer.

_____

3 Suggest a scenario that demonstrates the direction of water pressure.

_____

4 Explain in detail how an object floats or sinks. Use the words **upthrust**, **pressure**, and **weight** in your answer.

_____

_____

_____

5 Explain the changes in water pressure experienced by a diver in terms of particles, density, and water pressure.

_____

_____

_____

6 Predict whether an object that spreads over a large surface area but with many holes in contact with the water will float or sink. Explain your answer using as many scientific terms as possible.

_____

_____

_____

_____

Pressure on solids

Hi Mum

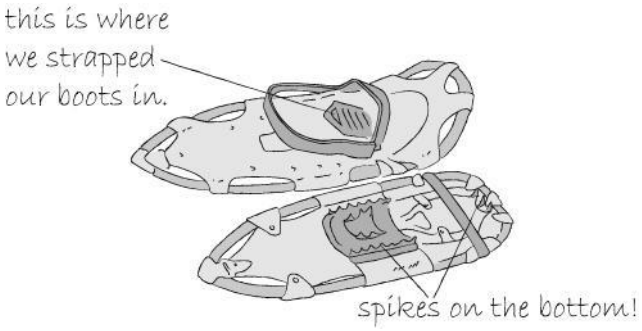
We tried the snowshoes today. They are big things we strap to our boots and they stop us sinking in the snow. Some of the other people didn't have them and they sank in up to their knees!

We went right to the top of the mountain. The snow was really hard near the top, but luckily the snowshoes have little spikes underneath so we didn't slip at all.

There were some people near the top trying to climb up an icy wall. They had spikes strapped to their boots, and ice axes that they dug into the ice. It looked very hard! There were some other people skiing down the hill.

We had lunch near the top. It was so cold I had to use my knife to cut the chocolate. It was nearly dark when we got back to the village. A boy had fallen through the ice on the pond. A man put a ladder down on the ice and crawled out along it. There was a huge crowd! They all gave a cheer when he pulled the boy out.

Love from Alex



1 a Underline all the parts of the letter that show the pressure being made less.

b Put a box around all the parts that show the pressure being increased.

2 Underline the correct words in the brackets.

a In the parts underlined, the pressure is reduced by making the (area bigger/area smaller/force smaller).

b In the parts with boxes around, the pressure is made bigger by making the (area bigger/area smaller/force smaller).

3 Look at the drawing of the snowshoes. Draw circles around the parts that make the pressure higher under them.

4 How did a knife help Alex to cut the chocolate?

5 How did the ladder help the man to crawl on the ice without falling in?

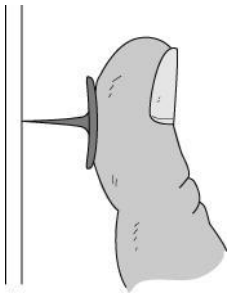
6 Complete these sentences by crossing out the words that are wrong.

a The snowshoes have a (large/small) area so the pressure under them is (high/low) and the person does not sink into the snow.

b The crampons have spikes on the bottom. The area of the spikes is (large/small) so the pressure under them is (high/low). This helps them to grip the ice.

c The point of the drawing pin has a (large/small) area. The pressure under the point is (high/low), which helps it to go into the wall.

d The head of the drawing pin has a (large/small) area. The pressure here is (high/low) so that it does not hurt your thumb.



e You can increase the pressure by making the force (bigger/smaller) and the area (bigger/smaller).

f You can decrease the pressure by making the force (bigger/smaller) and the area (bigger/smaller).

7. Fill in the following table using the equation pressure = force / area

Object	Force (N)	Pressure (N/m^2)	Area (m^2)
Tank	2,000,000		10
Cat	15	5	
Hamster		1	0.5
Dr Nicklin	300		1.5
Ant		0.1	0.01
Elephant	5000	1000	

8. The pressure you calculated for your feet is for standing still. Describe how this pressure would be different if you

a) walked

b) ran

c) jumped

9. The pressure under a tanks tracks is much higher than that for a car. Tanks have large tracks to reduce the pressure they exert on soft ground.

Explain how these two statements can both be true.

Convection

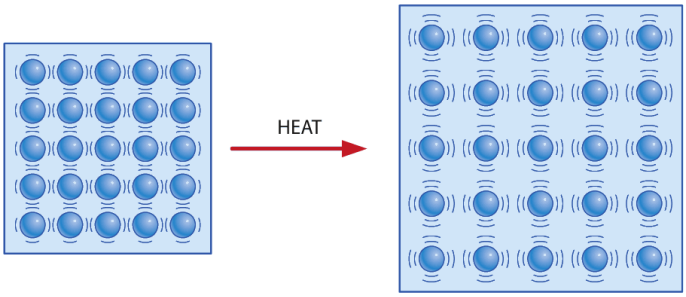
Liquids and gases like solids are made of particles, in a liquid and a gas the particles are not held in position and so can move around.

A fluids density changes with temperature.

Expansion:

- Many substances expand when heated.
- When heated, the particles (atoms or molecules) in a substance vibrate more.
- This means they need more space.
- So the substance expands.

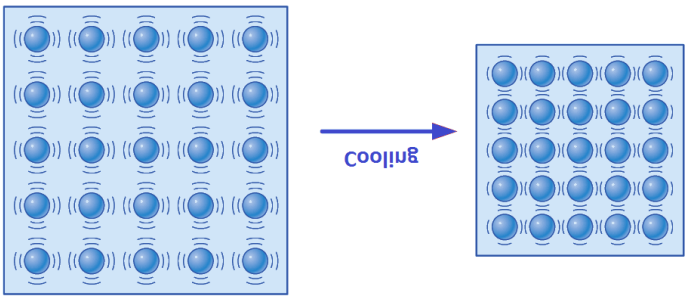
The density has decreased as the particles are further apart.



Contraction:

- Many substances contract when cooled.
- When cooling, the particles (atoms or molecules) in a substance vibrate less.
- This means they need less space.
- So, the substance contracts.

The density has increased as the particles are closer together.



When heat rises, it does so because of convection. Convection is a process explaining how thermal energy moves through out liquids and gases, it can be broken down into simple steps.

1. A fluid is heated so its particles begin to move around faster.
2. AS they move faster the particles move away from each other and the fluid expands.
3. Because the particles have moved away from each other the density of the fluid drops. This causes it to rise above the denser fluid above it.
4. As the fluid is no longer near a heat source its particles begin to lose thermal energy and hence slow down.
5. The slowing particles move closer together meaning the density goes up and the fluid sinks below the less dense fluid beneath it.
6. The process will then repeat itself.

This recurring process is known as a convection current and explains how thermal energy moves throughout a fluid.

Task 1: Complete the two diagrams to show what happens when particles are heated and cooled.

The density _____ when a substance is heated up.

The density _____ when a substance cools down.

Task 2: Place the following statements in order

In Convection:

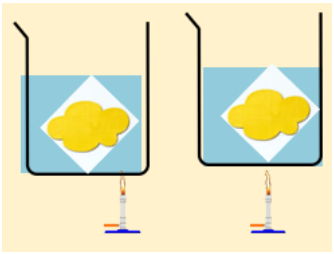
1. The less dense water rises.
2. When a substance is heated it expands.
3. Warm water is less dense.
4. When it reaches the top it cools and contracts.
5. The denser water sinks.
6. The cycle of rising and falling is the convection current.

Task 3: Draw and label a diagram showing convection in water

Task 4: For these examples, draw the movement of particles

Task 5: Independent practice

1. In which states of matter can convection take place? Solids, liquids, or gases?
2. Describe what happens to the particles when they are first heated.
3. Explain what happens to the particles after this and why it is an example of a cycle.
4. Describe how a convection current would form in these 2 containers.



5. Explain what causes each step to occur.
6. Why can't convection occur in solids?
7. Applying: Explain how the Earth's hot core causes earthquakes.
8. Give one example of when convection is useful in everyday life or one when it can be dangerous.
9. In each case, explain how the convection current is useful or dangerous.