

Background information

Year 5, unit 1: Solids, liquids and gases

Matter

The Earth and everything on it are made of matter. Matter is anything with mass and volume; it takes up space. There are three traditionally identified states of matter – solid, liquid and gas. Scientists have been investigating matter under very high temperatures and pressures such as those found on the Sun. On the Sun, matter behaves differently than in a solid, liquid or gaseous form and is known as a plasma (another state of matter). Whether something is in a solid, liquid or gaseous form depends on both pressure and temperature. More recently scientists have been investigating matter at very, very low temperatures, close to absolute zero (the coldest temperature possible). They have found that at extremely low temperatures matter also behaves quite differently and have defined another state of matter called the ‘Bose-Einstein condensate’. For more information see:

‘[Bose-Einstein condensate](http://www.chem4kids.com/files/matter_becondensate.html)’, Chem4kids website,
http://www.chem4kids.com/files/matter_becondensate.html (2012).

Solid

A solid has a fixed shape and a fixed volume. Solids do not have to be hard. A soft toy is also a solid as it has a fixed shape and a fixed volume. Solids can be any size or shape.

Sand is a solid that has the ability to be poured like a liquid and take the shape of its container. It is still a solid, as each individual grain of sand has a shape of its own and keeps that shape. In the case of things such as sand, salt and sugar, when you pour them from a container they will create a pile on the floor or bench top due to each individual grain having its own shape. When liquids are poured onto the same surface they are not able to create a pile, as they have no shape.

Liquid

Liquids have a fixed volume but no definite shape. They take on the shape of the container into which they are placed. A liquid also always goes to the lowest possible point of the container into which it is placed because the force of the gravity is stronger than the energy contained in the liquid.

Gas

Gases have no fixed shape and no fixed volume. Gases spread out to fill the space of the container they are in. If you fill a balloon with air, the gas will be evenly distributed in the balloon. If, however, you fill a balloon with water, the water will sit in the bottom of the balloon. The majority of gases are invisible and odourless.

Changing states of matter

All matter can change from one state to another under the right conditions, for example, from a solid to a liquid, from a liquid to a gas or from a liquid to a solid. This

is dependent on the temperature and pressure. Changes occur when certain temperatures are reached. If enough heat is added or removed, then a change in state will occur. To change a solid, such as a block of ice or a rod of steel, to a liquid, enough heat has to be applied to do so. The temperature at which the change of state occurs is called the 'melting point'. To change the water back to ice or the molten steel back to a solid, heat has to be lost or removed. The temperature at which this change occurs is exactly the same as the temperature for melting and varies according to the substance involved. For example, ice melts to form liquid water at 0 °C and liquid water freezes to form ice at 0 °C while the melting point of iron, the main component of steel, is 1535 °C.

Goo: a non-Newtonian fluid

The majority of liquids are known as Newtonian fluids. This relates to their viscosity, which is a measure of the fluid's resistance to flow. In a Newtonian fluid, the viscosity of the fluid stays constant even when a force is applied. Whether you are stirring water vigorously with a spoon or allowing it to sit in the bottom of the container, its viscosity does not change. It is no harder or easier to stir.

By combining cornflour and water you create a non-Newtonian fluid. With a non-Newtonian fluid the viscosity of the liquid changes depending on the amount of stress you place on it. The cornflour and water mix is a stir-thickening fluid. This means that as you place pressure on the fluid by stirring, its viscosity changes and it becomes thicker and is therefore more difficult to stir. As soon as the force is removed – you stop stirring – it becomes liquid once again. This is because the particles within the fluid lock together when a force is applied. When the force is removed they are able to move over each other in a more fluid motion.

How is gas used?

We are surrounded by gas. The atmosphere is a mixture of gases that form a layer around our Earth. Without this we would not survive. The different gases in the atmosphere absorb ultraviolet radiation and retain heat that warms the surface of the Earth. The atmosphere contains many gases including: nitrogen, oxygen, carbon dioxide and helium.

People use natural gas to heat their homes and to cook their meals. This gas is found beneath the surface of the Earth. It is extracted from the Earth using wells and then processed to remove the impurities. It is then compressed and provided to homes via a network of underground pipes or in gas storage bottles.

We use gases in lots of other ways in our lives. The soft drinks that we drink are fizzy due to the carbon dioxide gas that is added. The bubbles of carbon dioxide give the drink the fizz. When you open the drink you can hear the gas escaping and when you pour the drink into a glass you can see the bubbles of carbon dioxide rising to the surface where they burst and dissipate.

Some people use gas to fuel their cars and as a fuel when cooking on a barbecue. Aerosol cans, such as those that contain fly spray, paint or hair mousse contain gas,

as a propellant, which is stored under pressure. Within the can there is a tube that goes from the nozzle to the bottom of the can. When you push on the nozzle the pressurised gas tries to escape but because the liquid is in the way, the pressurised gas forces the liquid up the tube and out of the nozzle.

Gases are also used in things such as bicycle and car tyres, anaesthetics, balloons, lightglobes and SCUBA diving. There are many other ways that gases are used as part of our lives.

Why is gas compressed?

Gas can be easily compressed with very little effort. By compressing gas and forcing it into tubes and cylinders, we can use it more efficiently. For example, by compressing air, which is a mixture of gases, into a cylinder, divers can use it to breathe underwater. When the air is compressed and under pressure the gases rush out to normalise the pressure, but the flow of the air is regulated so the diver doesn't receive too much at once. If the air was not compressed it would not be under enough pressure to force its way out of the cylinder.

Lesson 2: Investigation procedure

How do substances change when heated and cooled?

Materials (per group)

- 4–6 different common household liquids such as:
 - water
 - salt water
 - fruit juice
 - soft drink
 - vinegar
 - tomato sauce
 - salad dressing
 - yoghurt
 - cordial

(Ensure all groups have the same four liquids so that the data collected can then be easily compared across the class.)

- ice cube tray
- 4–6 foil pie trays
- 2 tea light candles
- 1 large wooden clothes peg
- 1 stopwatch or timing device
- access to a freezer

Procedure

1. Pour an equal amount of each of the liquids into an individual section of an ice cube tray.

2. Place the tray in the freezer and start the timer.
3. Regularly make and record observations about what is happening to the liquids in the tray, remembering that the longer the tray is removed from the freezer the longer the freezing process will take.
4. Once the liquids are all frozen, remove them from the freezer one cube at a time to begin the heating process.
5. Ask the teacher to light the tea light candle. Place the block of frozen liquid into a foil pie tray and hold the pie tray with the peg over the candle. Start the timer to record the time taken for the ice cube to melt.
6. Record key observations about what is happening and at what time, for example, when did you see signs of it melting? How long did it take to be completely melted?
7. Once the ice cube is completely melted and back in a liquid state, restart the timer to begin timing the evaporation process.
8. Record key observations about what is happening and at what time, for example, how long did it take to completely evaporate?
9. Repeat the same process with the remaining frozen liquids.

Fair testing

Students complete the following table during the investigation.

| What variable will I change? | What variables will stay the same? |
|------------------------------|------------------------------------|
| | |

Variables to consider

- Use the same liquids.
- Use the same amount of liquid.
- Take the ice cube tray out of the freezer for the same amount of time to make observations.
- Hold the foil tray the same distance from the flame each time.

Data collection

| Liquid | Time taken to freeze | | | | | | |
|--------------|----------------------|--------|--------|--------|--------|--------|--------|
| | Team 1 | Team 2 | Team 3 | Team 4 | Team 5 | Team 6 | Team 7 |
| water | | | | | | | |
| fruit juice | | | | | | | |
| tomato sauce | | | | | | | |
| salt water | | | | | | | |

| Liquid | Time taken to melt | | | | | | |
|--------------|--------------------|--------|--------|--------|--------|--------|--------|
| | Team 1 | Team 2 | Team 3 | Team 4 | Team 5 | Team 6 | Team 7 |
| water | | | | | | | |
| fruit juice | | | | | | | |
| tomato sauce | | | | | | | |
| salt water | | | | | | | |

| Liquid | Time taken to evaporate | | | | | | |
|--------------|-------------------------|--------|--------|--------|--------|--------|--------|
| | Team 1 | Team 2 | Team 3 | Team 4 | Team 5 | Team 6 | Team 7 |
| water | | | | | | | |
| fruit juice | | | | | | | |
| tomato sauce | | | | | | | |
| salt water | | | | | | | |

Data Representation

Once students have collected and recorded the necessary data and observations from the investigation, meet together as a class to discuss how this data can be best represented. Can the information be graphed? What type of graph would be best?

Conclusion

Ask students to look at the data they have collected and respond to the following questions.

- Can any conclusions be drawn?
- Was there anything that surprised you?
- How does the data relate to your earlier predictions?
- Is there anything that could be done to improve the data collection?

Lesson 3: information on the mini-investigation

When an inverted glass is pushed into a container of water, air remains trapped inside the glass. This air takes up space and therefore does not allow the water into the glass. If the glass is tipped slightly to one side some of the air has a chance to escape from the glass and is replaced by water. The air that escapes rises as a

bubble to the surface of the water.

Lesson 4: information on the mini-investigations

Gases can be easily compressed whereas liquids cannot. Trying to clap hands in the air and under water demonstrates this to students. It is much easier to move your hands quickly through the air and clap them together than it is to move them through water to do the same thing.

If you fill a syringe with air and place a finger over the end, you will be able to easily press the syringe down because the air inside the syringe is easily compressed. If you fill the syringe with water, put your finger over the end and then try to push the syringe down, you will notice it is much harder to move the syringe any distance. This is because water is much harder to compress than air.