Chapter overview

In this chapter students are introduced to the concept of substances and their physical and chemical properties. Students will describe matter in terms of particles, outline how particle movement is related to energy, and use the particle model to predict what happens when substances are heated or cooled. Students will explain how the physical properties of matter change with changes of state, use the particle model to explain density, and list the benefits and limitations of models in terms of the three states.

Content identified by the New South Wales Syllabus as Additional is covered in this chapter, including how traditional Aboriginal and Torres Strait Islander communities use natural materials in daily life, understanding gas pressure, and considering the historical developments in understanding the particle model.

Pre-prep

The practical investigations will require chemical preparation, so check the requirements before each one. Some could be performed simultaneously, or in the same lesson with similar equipment.

Students will learn the most from this chapter if it is practical and demonstrated. A number of extra activities are included in the learning strategies to suit students' interests.

Prac 1 in Unit 2.1 requires PVA glue. It is worth checking what sort of PVA glue gives the best results, and what exact volume of water that it requires to make the best putty.

This chapter is expected to take 3 to 4 weeks.

Pre-quiz

1 **Explain** what causes fog or mist.

Water droplets in the air.

2 **Explain** why it is easy to squash an empty plastic soft drink bottle, but not a full one.

The 'empty' bottle is actually full of a gas (air). The particles in a gas are farther apart than in a liquid, so the empty bottle can be compressed more.

3 **Identify** what a model is used for.

To provide one explanation of a scientific phenomenon or observation.

4 **List** the three main states and give an example of each.

Solid (ice), liquid (water), gas (water vapour)

2 Properties of substances

Have you ever wondered...

- why solids, liquids and gases appear so different?
- why clothes dry even when it's not hot?
- why you breathe out fog on a cold morning?
- why icebergs float?

After completing this chapter students should be able to:

- describe matter in terms of particles
- outline how particle movement is related to energy
- use the particle model to predict what happens when different states of matter are heated or cooled
- explain how the physical properties of matter change during changes of state
- explain density in terms of the particle model
- identify the benefits and limitations of using models to explain solids, liquids and gases CCT

ADDITIONAL

- research how Aboriginal and Torres Strait Islander peoples use the physical properties of natural materials in everyday life AHC
- investigate how the chemical properties of a substance affect its use
- explain how gas pressure is related to the frequency of particle collisions
- outline historical developments that have advanced our understanding of the particle model.

What's coming up

In this chapter students look at aspects of the physical and chemical properties of substances, including:

- describing matter in terms of its physical and chemical properties
- solids, liquids and gases
- the particle model of matter
- changes of state and how they occur
- the concept of density.

Future topics that build on this information are The water cycle in Chapter 3 and Chapter 4 Mixtures.

RESOURCES

Pearson eBook

Teacher support

A comprehensive mapping of *Pearson Science New South Wales 7* against the NSW Syllabus for the Australian Curriculum and detailed teacher programs are available on Pearson eBook. These documents can be edited and adapted to suit the needs of your students and the requirements of your school.

Chapter 2 safety notes and risk assessments

This single document contains safety notes and risk assessments for all Practical investigations in Chapter 2.

Weblinks

These websites support Chapter 2.

2.1 Physical and chemical properties

There are millions of different substances in the world. Each can be identified by its properties. Properties describe a substance and how it acts. They include its appearance, what it does when heated or cooled, and how it reacts with other substances.

INQUIRY science 4 fun

What is foam?

Is shaving foam a solid, a liquid or a gas?

YES

Collect this ...

- can of shaving foam
- plate (not paper)
- small mass (such as a 50c coin or a pebble)

Do this ...

1. Squirt a blob of shaving foam onto the plate. What does it look like? Does the foam flow or change shape without being pushed around?
2. Place the small mass on the top of the foam. Does it stay there or does it sink?
3. Squirt another blob of foam onto the plate. Put the plate into a cupboard so that it won't be touched. Leave it there overnight. What does the foam look like the next day?

Record this ...

Describe what happened.

Explain why you think it happened.

Physical properties

You can probably tell which objects and substances around you are solid, liquid or gas by the way they look and act. What you see are **physical properties**. Testing a substance for its physical properties doesn't destroy the substance, or change it into anything new.

Some of the most useful physical properties of a substance are:

- whether it's a solid, liquid or gas at room temperature (normally taken as 25°C)
- the temperatures at which the substance freezes or boils (known as its freezing point and boiling point)
- its appearance (such as its colour and texture, the shape of any crystals within it and whether it is shiny or dull)
- its density (how heavy it is compared to other substances of the same size)
- how hard or brittle the substance is (whether it is easily scratched or whether it crumbles)
- whether the substance dissolves in different liquids (known as solubility)
- its ability to let heat or electricity pass through it (known as its thermal and electrical conductivity).

Vocabulary preview

biodegradable
chemical properties
compressed
incompressible
non-biodegradable
odour
physical properties
plasma
states (phases)

Learning strategies

Literacy strategy

Asking questions

MI: Verbal/Linguistic

Before reading, have students rewrite the section headings as How, What and Why questions about the particle model. For example, the first heading, 'Physical properties', could become 'What is a physical property?' or 'How do physical properties relate to what an item does or is?' As they read, students should write answers to their questions.

RESOURCES

Skills support

Science and Inquiry 1 has additional support for identifying change.

Science and Inquiry 1 Skill 6.1

science 4 fun

What is foam?

Background

Shaving foam has the characteristics of a solid, liquid and gas. There are pockets of gas inside bubbles of liquid that give it a frothy look and feel, while it will hold still (to some extent) if not touched, blown on or pushed. The gas between the foam holds it up but the liquid itself will not hold still like a solid.

In this chapter students will be investigating all three states, but there are examples like foam where a substance has characteristics of more than one state, or is made up of more than one substance, each with a different state.

Hints and suggestions

Ask students why they have been told not to use a paper plate. What would happen to the paper plate with the foam? Think about the liquid aspect of the shaving foam. Some of the foam would be absorbed by the plate.

Different parts are not really solid, liquid and gas. There is no part of the foam that is a solid, but the whole 'foam system' can act like a very weak solid, provided external forces are not sufficient to make it act like a liquid.

Possible results and looking forward

Students should find that the small mass sinks through the shaving foam.

When students leave the shaving foam overnight they should find that the liquid component has evaporated. A solid, though thin and still weak, will remain in the form of the soap.

Foam has characteristics of all states. Hence this activity helps students to understand that not all substances can be classified as purely solid, liquid or gas. Help students break down what parts of the foam are solid, liquid or gas and how they go together in this situation.

Using models

Physical properties

MI: Verbal/Linguistic, Logical/Mathematical

Have students use the bullet list on page 43 to make a tick or flick list of physical properties to use each time they are attempting to identify and record an item.

Extra support

Concept maps

MI: Visual/Spatial, Logical/Mathematical, Verbal/Linguistic

Have students draw a concept map for solids, liquids and gases. Surround each word with examples of that type. Then use arrows to join how they change state as that is explored throughout Units 2.2 and 2.3. This will help students link it all together, and visual learners will relate to this presentation.

Using visuals

Describing

MI: Visual/Spatial, Verbal/Linguistic, Intrapersonal

L

Ask students to study Figures 2.1.1, 2.1.2 and 2.1.3 and then describe in their own words the difference between the particles in solids, liquids and gases.

Extra information

Raindrops

The SciFile describes how rain doesn't fall in the shape of teardrops. Raindrops start as round shapes but change shape because of air resistance and the flow of air around the drops as they fall through the atmosphere. Raindrops have a more flattened bottom and rounded top until they are ripped apart.

Solids, liquids and gases

Substances exist in either solid, liquid or gaseous form. These forms are known as the **states** (or phases) of matter.

Solids, liquids and gases have very different physical properties. Think of the van in Figure 2.1.1. The bodies of cars and vans only change shape when they are in an accident or when they are broken up to be recycled. Also solids cannot be **compressed** (squashed to make them smaller). Try to compress a sugar cube and it might crumble, but the volume of sugar is exactly the same as it was before. The fact that solids do not change shape or size allows them to be used to build structures.

Liquids are similar to solids in that they don't change their size and are **incompressible** (unable to be compressed or squashed). They differ from solids in that they can flow and change shape. Think of orange juice: it splashes about and can be poured from one container into another, taking on a new shape as shown in Figure 2.1.2. The ability of liquids to squeeze along pipes and hoses without changing volume allows them to be used in hydraulic (powered by liquid) systems such as car brakes.

No teardrops!

The shapes of raindrops change as they change size. None of them looks like the teardrops shown in the weather report!

Diameter (mm)	Less than 1	1 to 2	2 to 4.5	Bigger than 4.5
Shape				

SciFile

Solids:
- have a fixed shape
- have fixed size and volume
- cannot be compressed (pushed in to make it smaller)
- will usually sink when placed in liquids of the same material.

Figure 2.1.1 The bodies of cars and vans are solid. They don't change shape or size unless they are in an accident or they are crushed to be recycled.

Liquids:
- have fixed size and volume
- are able to flow
- take the shape of the bottom of the container they are in
- are incompressible (not able to be compressed).

Figure 2.1.2 Liquids always flow to take up the shape of their container.

Gases are often invisible and many have no **odour** (smell). Water vapour is a gas that is invisible because it is colourless and its particles are spread too far apart for the gas to be seen. However, you can feel water vapour since it gives air its humidity. There is a lot of water vapour in the air on a humid day, making you feel sweaty and sticky. Figure 2.1.3 shows a mixture of gases that does have a smell.

Gases differ from solids and liquids in that they can be compressed. This property allows gases to be squeezed into small volumes such as barbecue gas cylinders. It also makes them useful in the gas struts or shock

RESOURCES

Pearson eBook

P

Interactive activity: Liquid or solid
This interactive activity investigates the difference between solids and liquids.

Interactive activity: Solids, liquids and gases
This interactive looks at the differences between the three states of matter.

Worksheet 2.1: Solids, liquids and gases
A worksheet on identifying the three states of matter, with full answers, is available in addition to the worksheets included in the Activity Book.

absorbers found in the suspension of bikes and cars. A bump compresses the gas in the struts, softening the impact of the bump. The gas then expands once more, pushing the strut back to its original shape.

Prac 1 p. 50 Prac 2 p. 51

Gases:
- are often colourless and invisible (you may be able to detect their smell)
- will spread out to take the shape of the container
- have no fixed shape or volume
- can be compressed (pushed in to make them take up a smaller amount of space).

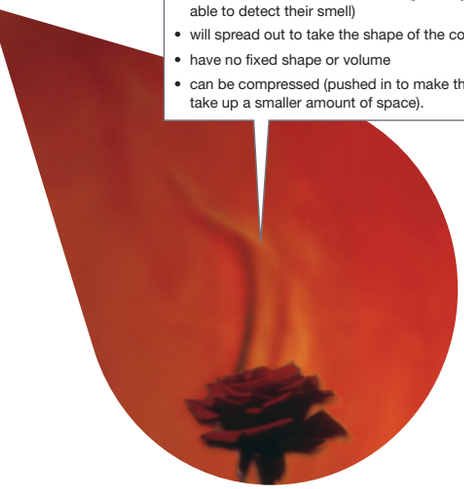


Figure 2.1.3 Perfume, smells, vapours and fumes are all gases. This image shows the gaseous perfume rising from a rose.

The fourth state

There is a fourth state of matter but it is very rare on Earth. **Plasma** is a gas-like state that only exists at temperatures above 6000°C, making it common on stars but not here.

SciFile

Figure 2.1.4 On Earth, plasma is found wherever high-voltage sparks are generated such as lightning bolts or in this plasma sphere.

Chemical properties

Chemical properties describe how a substance reacts with other substances. A new substance is formed in the process, often with very different properties. For example, iron rusts because it combines with oxygen and water. Iron is grey, hard and often shiny, while the rust it forms is red-orange, flaky and brittle. Likewise, paper burns and dynamite explodes, leaving behind ash and smoke.

Chemical properties that are worthwhile knowing about are whether a substance:

- burns or explodes in oxygen (this is known as combustion)
- rusts or corrodes (known as corrosion) or is corrosion-resistant
- is an acid like vinegar or a base like bicarbonate of soda or neither (this is measured by its pH)
- reacts quickly or slowly with other chemicals (this is known as the rate of reaction). Explosions like the one in Figure 2.1.5 have a very fast rate of reaction.

Figure 2.1.5 The chemical properties of LPG and petrol cause them to explode when there is plenty of oxygen and a flame or spark to start it off.

RESOURCES

Practical investigations

Prac 1 on page 50 gives students the opportunity to make slime and observe its properties.

Prac 1 p50

Prac 2 on page 51 examines the properties of oobleck.

Prac 2 p51

Activity Book

2.1 Plasma: the fourth state of matter
MI: Verbal/Linguistic
LATC: Literacy, critical and creative thinking.

2.1

Learning strategies

Using models

Chemical properties

MI: Verbal/Linguistic, Logical/Mathematical

CCT PSC

Have students use the bullet list on page 45 to make a tick or flick list of chemical properties to use each time they are attempting to identify and record an item. Use this list each time they record an item, even when in groups. Have students share their tick or flick lists; they should all be fairly similar.

ICT

Plasma

MI: Verbal/Linguistic

CT

Have students research plasma in the stars, including looking at images. Have them find three pieces of information and justify why they think that plasma is considered the 'fourth state.'

Creating

Complete sentences

MI: Verbal/Linguistic

CCT

Encourage students to be creative and help them to understand the concepts of gases by completing sentences such as these:

1. Gases are important in the following industries: .... *(for example, perfume, flowers and nursery)*
2. Gases are a problem in the following situations ... *(for example: The gases released by some products during different manufacturing processes can be problematic.)*
3. An example of a gas I interacted with today is ... *(for example: carbon dioxide, when I drank a can of soft drink)*

Creating

The right substance—a story

MI: Verbal/Linguistic

CCT L

After reading about the importance of using the right substance for each purpose, do the following activity for a bit of fun. Ask students to create a story of what would happen when the wrong substance is used for building something. Make the story realistic, but feel free to be comical.

Give them an example such as the one from Figure 2.1.6, which asks us to imagine that the jumping castle is filled with lead instead of water.

One day a jumping castle was accidently filled with lead. After the assistant completed filling it, he leant against it and stubbed his toe. Oh dear. Next a teenager climbed on it and when he jumped it made a funny noise. 'Ding ding ding.' He touched the bottom and it was cold. He flopped on his bottom and yelled 'Ow!' Perhaps lead was a bad idea! The jumping castle was shut down.

science 4 fun

The weight of a gas

Background

All matter has mass, even a gas. Particles in gases are spaced a long way apart and loosely packed, so a volume of gas will have much less mass than the same volume of a liquid or solid. We don't feel gases as they do not have enough mass to pull or push us down, but they still exist. This experiment should show this to students.

Hints and suggestions

Puncturing a partially inflated balloon and letting the air out slowly will show the effect slowly. The balloon will probably 'pop' if it is inflated enough to stretch the rubber until it is fairly rigid.

Possible results and looking forward

The balance should drop towards the side that still has an inflated balloon. Start the discussion with questions such as 'What does this mean? Is the mass of these particles affected by gravity?'

Choosing the right substance

The different properties of substances affect how they are used. For example, the frame of a skyscraper needs to be solid and strong and so is commonly made out of steel. Shopping bags are made of plastic, paper or fabric because they need to be cheap, light, strong and flexible. Likewise, takeaway food containers are often made of polystyrene because it's light and keeps the heat in.

Sometimes liquids or gases will be a better choice than solids. For example, car brakes only work because liquid is pumped through tubes to activate them, while a gas (air) is used to keep a jumping castle in shape. Imagine if the jumping castle shown in Figure 2.1.6 was filled with lead!

Figure 2.1.6 The walls and floor of a jumping castle need to be solid and strong but also smooth and flexible. Inside is a gas (air) that can compress when you jump on it but which will expand as soon as you jump to another spot.

INQUIRY science 4 fun

The mass of a gas

Does gas have mass?

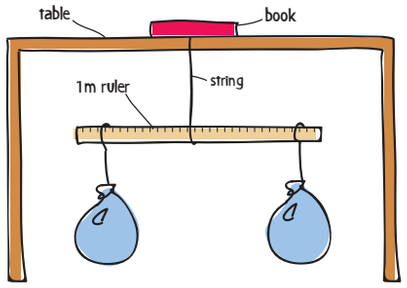
YES

Collect this…

- 2 balloons
- 3 lengths of string (each about 30 cm long)
- 1 m ruler
- needle (sharp enough to burst a balloon)

Do this…

1. Inflate both balloons until they are roughly the same size.
2. Tie their ends and tie a piece of string to the top of each balloon.
3. Tie one balloon to one end of the ruler and the other balloon to the other end as shown in the diagram. Use the ruler markings to make sure that the strings are the same distance from the ends of the ruler.
4. Tie the third string to the middle of the ruler and hang the ruler from the edge of a table.
5. Balance the ruler so that it hangs parallel to the floor. Do this by sliding the middle string along the ruler until you find the balance point.
6. Puncture *one* of the balloons with the needle and observe what happens.



Record this…

Describe what happened.

Explain why you think this happened.

ADDITIONAL

LEARNING ACROSS THE CURRICULUM

SUSTAINABILITY

BIODEGRADABILITY

Leave a sandwich in your schoolbag and a few days later you'll be left with a mess of rotting, smelly goo.

Figure 2.1.7 Rot and mould are signs that a substance is biodegradable.

This happens because microscopic bacteria cause chemical reactions that break down substances in the sandwich into simpler substances like sugar, water and carbon dioxide. However, the cling wrap or plastic container holding the sandwich is unlikely to have changed. The chemical properties of the bread, lettuce and tomato caused them to rot, while the chemical properties of the cling wrap or plastic gave them rot-resistance.

BIODEGRADABLE

Substances are classified as being **biodegradable** if bacteria or fungi break them down. Fruit, vegetables, flowers, wood, twigs and leaves are biodegradable since they all break down quickly. This is why they are put into composts: they break down, forming simple substances that can then be used to fertilise other plants. The mould on the strawberry in Figure 2.1.7 shows that it is biodegradable. Animals are biodegradable because bacteria quickly break them down into simpler substances once they die.

Anything made of natural, living substances (or from substances that once lived) is usually biodegradable too:

- paper and cardboard (made from wood)
- cotton, hessian, linen fabrics (made from plants)
- woollen fabrics (the 'hair' of animals like sheep and goats)
- soaps (made from natural fats and oils).

NON-BIODEGRADABLE

Non-biodegradable substances eventually break down but often take hundreds of years to do so. Non-biodegradable substances have structures that bacteria and fungi cannot pull apart. Even though most plastics are made from a long-dead natural substance (crude oil), their structures are too different from the structures of living substances for them to be biodegradable. Other non-biodegradable substances are:

- polyethylene cling wrap (used to wrap sandwiches)
- most plastic shopping bags
- wrappers (used for lollies, chocolate bars and ice-creams)
- polystyrene (used for takeaway food)
- house paints
- glass (used for soft-drink and sauce bottles)
- metal cans (used for soft-drinks and canned spaghetti).

Anything made from these substances remains in the environment as rubbish and pollution for many, many years. They might crush, break or rip into smaller pieces, but their chemicals are still there polluting the environment for a long time.

Questions

1 Which items went mouldy first?

Answer will depend on the food items being tested. Bread, cheese and pumpkin are likely to become mouldy quickly.

2 When is the best time to eat fresh food?

When it is fresh!

3 What did this tell you about lollies?

Lollies must contain a preservative—something that 'preserves' it, i.e. stops it from going mouldy or rotten. (Sugar is a very effective preservative. Although many lollies contain flavours and colours, most do not have any other preservative except sugar.).

ADDITIONAL

Summarising

The big question…

MI: Verbal/Linguistic

L

What is the 'big question' to ask to work out if something is biodegradable or not?

Does the item come from living material? If the answer is yes, it is!

Inquiry activity

What does mould look like?

MI: Visual/Spatial

Purpose: To make observations of food and the timing of mould changes

Class time: 5 minutes set up, observation over time

Materials: Any food item from home, such as bread, cheese, apple, pumpkin, tomato, cake or lollies

Hypothesis: Which food items do you think will go mouldy first? Write a hypothesis before you begin.

CCT

Ask students to each bring a small food item such as one of those listed above. Alternatively, provide the items yourself so that you can be sure of a good range for this activity. Make sure some longer-lasting foods such as lollies are available too. Do not use meats or meat products, because they may become rancid and attract flies. Also do not allow students to bring nuts because of the potential problem with food allergies.

Put all these items on a large tray and leave them out for an indefinite length of time. Keep in mind that they might smell.

Extension

Biodegradable information poster

MI: Verbal/Linguistic, Visual/Spatial, Interpersonal

CCT

After reading the Learning across the curriculum, ask students to create a poster to share information with the public about making good decisions on the use of non-biodegradable packaging and so on. Plenty of information is provided on page 48 on what we can do, but if time permits students could research or discuss other ideas they have found.

Students should prepare a poster or PowerPoint presentation that could be used in a public area. Have students suggest where they could use their presentations in public to inform people about packaging.

Posters could be displayed in cafeterias or near them, in shopping centres and so on. Also they could be displayed in information sessions and science laboratories. Student answers will vary.

ADDITIONAL