7G
The particle model

This unit develops an understanding of the different properties of solids, liquids and gases within the context of waste management and disposal. Scientific method and ideas on experiments, observation, hypotheses and theories are discussed, leading to an understanding of the particle theory of matter. Further applications of the particle theory are investigated using the context of waste and waste disposal.

Recommended teaching time for unit: 7.5–10 hours

There is an opportunity for focused development of communication skills in Topic 7Ga. A similar opportunity focusing on the skills of working as a scientist is found in Topic 7Gb. You may wish to spend additional time on these units should you feel that your students would benefit from these skills-development opportunities.

From KS2 most students will be able to:

- compare and group materials together, according to whether they are solids, liquids or gases (Year 4)
- understand that some materials will dissolve in liquid to form a solution, and describe how to recover a substance from a solution (Year 5)
- use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating (Year 5).

Topic 7Ga describes the different properties of solids, liquids and gases, in terms of shape, volume and compressibility. It is presented in the context of waste management and disposal. It also includes a section on how scientists use language effectively to measure and compare.

Topic 7Gb explains the concepts of hypotheses and theories in the context of scientific methods and introduces the particle theory of matter to explain the basic properties of solids, liquids and gases.

Topic 7Gc discusses Brownian motion, and how its explanation using particle theory finally established the theory within the scientific community.

Topic 7Gd uses the particle theory to explain diffusion in different situations.

Topic 7Ge looks at explanations and applications of gas pressure.

National Curriculum coverage

This unit covers the following statements from the UK National Curriculum for Science (2013):

- the properties of the different states of matter (solid, liquid and gas) in terms of the particle model, including gas pressure (Chemistry)
- similarities and differences, including density differences, between solids, liquids and gases (Physics)
- Brownian motion in gases (Physics)
- differences in arrangements, in motion and in closeness of particles explaining changes of state, shape and density, the anomaly of ice–water transition. (Physics)

In addition to covering a variety of Working Scientifically statements, this unit has a focus on:

- understand that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review
- make predictions using scientific knowledge and understanding
- present observations and data using appropriate methods, including tables and graphs.

Literacy & Communication skills

- how scientists use language to measure and compare by applying adjectives, comparatives and superlatives.

Maths skills

- converting between metres and nanometres
- calculating volumes using simple formulae.

Cross-curricular opportunities

7Ga – Geography – use of land
7Ga – History – changing nature of rubbish
7Ga – English – adjectives, comparatives and superlatives
7Gb – Geography – environmental pollution
7Gd – History – funding for science research pre 19th century
7Ge – Geography – air pressure and weather forecasting

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7G Background information

7Ga Solids, liquids and gases

This topic introduces the properties of the different states of matter, through the theme of waste and waste disposal. It considers the different properties of the three states of matter, allowing students to describe these based on their properties of keeping their shape, keeping their volume and how easily they are compressed.

There are a number of substances that are effectively combinations of two states of matter and some students may mention these. A suspension is a mixture from which the solid particles will settle slowly on standing. Flour in water is a good example. A colloid is a mixture where the particle size is between that of a suspension and a true solution. There are a number of types of colloids, with one substance dispersed in a medium. Unlike a suspension, the particles in a colloid do not separate out from the medium in which they are held.

7Gb Hypotheses and theories

After asking a question about a phenomenon, a scientist may propose a hypothesis to explain the phenomenon. In order to be 'scientific' the hypothesis must be able to be tested. The hypothesis can be used to generate a prediction which can then be tested.

If the tests are repeated over and over again in different contexts the hypothesis can be refined to produce more and more accurate predictions. Accurate hypotheses can then be grouped together to form an overall theory that can be further tested by new hypotheses.

The scientific method is any method in which ideas about things are tested. The flowchart in the Student Book shows how this often works.

In modern science, a successful test may lead to the production of a scientific paper, which is submitted to an appropriate journal.

Before publication, the paper is often subjected to anonymous peer review – the editor of the journal will send the paper out to other experts in the field, without revealing the authorship of the paper.

As a result of this process, the paper will be published, or returned to the author for amendment, or even rejected altogether. This system attempts to provide quality control over experimental procedure. However, this is based only on the experimenter's account of his or her methods. In the case of ground-breaking discoveries, or particularly controversial discoveries, other laboratories will attempt to replicate the experiment to check the results.

For some theories, the peer review process is the only means of quality control. Subjects such as the study of climate change cannot easily be made the subject of experiments, and only other experts in the field can check the assumptions made (in computer modelling, for instance).

Theories about such subjects can rarely be 'proven'. Even widely accepted scientific theories can be overturned by new observations. For instance, Newton's laws of motion were widely accepted for over 300 years, until Einstein proposed his theories of relativity. Even so, Newtonian mechanics are still widely used in engineering as they adequately describe motion for most practical engineering applications.

7Gb Particles

The particle theory or kinetic theory is the basis of most of our understanding of the behaviour of matter. All materials are made up of particles and it is the arrangement of these particles that decides the properties shown by the material.

All solids are made up of particles that are closely packed together, arranged in a regular pattern and are unable to move around. Each particle is continually vibrating about a fixed point but is held in place by strong bonds. As a result of these strong bonds between the particles, it is very difficult to move one particle relative to the others. This gives solids their properties: they have fixed shapes and volumes, do not flow, cannot be compressed and have high densities.

Like solids, liquids are composed of particles. However, the particles in a liquid are more mobile, being able to move past each other but still unable to break free. The particles are able to move because there are weaker bonds holding them together. The particles have been given more energy when compared with the corresponding solid, and have managed to break some of the bonds that were present in the solid structure. As a result, the particles are not arranged in a regular pattern and they are not as closely packed. The properties exhibited are increased fluidity, ability to change shape to the shape of the container, and lower density than the solid of the same substance*. However, they still have a fixed volume – the particles are still fairly close – and are difficult to compress.

(*The exception to this is water, which is denser than ice at 4 °C. This occurs as there are special hydrogen bonds between water molecules. These form an open lattice structure as water freezes into ice. Thus ice is less dense than the surrounding water. This has important consequences for pond life as ponds freeze at the top, leaving liquid water below.)

Hydraulic systems rely on the fact that liquids are difficult to compress. They work by transferring the pressure exerted on a liquid at one point to another point some distance away. Examples are the use of hydraulic lifts and the braking system of a car.

The viscosity of a liquid is a measure of how easily it flows, and depends on the strength of bonds between its molecules. In water molecules, the bonds between particles are fairly weak and so the particles can flow past each other quite easily. In general, the larger or the more complex the shape

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of the molecule, the more viscous the liquid will be. Stronger bonds between molecules reduce the ease with which they can slip past one another. Increasing the temperature provides energy to break more of the bonds, and hence reduces the viscosity of a liquid.

Gases are made up of particles that are free to move in any direction. There are no bonds holding the particles together, so they have no regular arrangement – they are moving randomly and will move to spread out into any available space. As the particles are well spread out, gases are quite easy to compress and have a lower density than either liquids or solids; they are very fluid, can change shape to fill any container and have no fixed volume.

Throughout the topic the particle theory of matter is discussed with reference to 'particles'. This is deliberate as some materials are composed of molecules with different atoms while others are giant structures of the same type of atom. If students have already come across the terms 'atom' and 'molecule', they could be told that we are using the word 'particles' as a general term so that we can explain the properties of substances like water (made from molecules) alongside those of, say, steel.

7Gc Brownian motion

This topic introduces the discovery and eventual explanation of Brownian motion. The observation is used to illustrate another observation that can be explained by the particle theory of matter. In addition it is an illustration of how theories are eventually accepted by scientists when they can be used to explain a large number of observations and evidence. Thus Brownian motion was the final proof of the particle theory of matter to many scientists.

The topic also introduces the idea of nanoparticles and the conversion of associated units: metres and nanometres.

7Gd Diffusion

Diffusion, like Brownian motion, is another consequence of the random motion of particles. If you start with a high concentration of a particular substance in one place, it is likely that the particles will spread out in all directions.

Diffusion occurs more quickly when the particles have more freedom of movement and are moving faster. Thus gases diffuse faster than liquids. Real solids will not exhibit diffusion, as their particles are fixed in position. However, some substances that 'look like solids', for example gelatine or cream, may appear to be involved in diffusion. For example the colour of hundreds and thousands can spread through cream and jelly.

Gases are less dense than liquids because the particles are more spread out. The bubbles we see rising to the surface when water boils are small pockets of steam formed as the water particles spread out as they are heated. The bubbles in a bottle of fizzy drink are similar. Carbon dioxide gas was dissolved in the drink under pressure and when the bottle is opened the pressure is released, letting the gas bubbles form and rise to the surface. Heating the drink will encourage more dissolved particles of gas to form bubbles. Similarly, cooling the drink will help to keep dissolved gas particles in the drink. However, if a bottle of fizzy drink is left open, it will eventually go flat as the gas bubbles will continually form until insufficient gas is left to form any more. This will happen more quickly if the drink is warm. If the lid is replaced, the amount of gas that can bubble away will be limited by the amount of space available above the gas in the bottle. A bottle that is two-thirds full will stay fizzy longer than a bottle that is only one-third full.

7Ge Air pressure/Waste

Pressure in a container of gas is the effect of the moving particles hitting the walls of the container. The pressure in a gas can be increased in a number of ways. If the volume of the gas is reduced, then the particles have less distance to travel between each collision and so hit the walls more often. If the temperature of the gas is increased, the particles will move faster and will hit the walls more often. They will also hit the walls harder as they have more momentum. However, for the sake of simplicity, this is not mentioned in the teaching materials. If the number of particles inside the container is increased, there are more of them to hit the sides of the container and so the pressure will rise.

The pressure of the air around us is called air pressure or atmospheric pressure. The latter term is not used in this unit. In this course, the pressure of a gas *inside a container* is called gas pressure. Air pressure, caused by the particles of air hitting your body, is all around you. The pressure is from all sides and directions. You do not notice it, because you are so used to it. Air pressure can change, that is why weather forecasters refer to high-pressure and low-pressure weather systems.

There are also gas pressures inside you, for instance in the middle ear. Normally, the gas pressure in the middle ear is the same as the air pressure in the surroundings. The surroundings and the middle ear are connected together by the Eustachian tube, which can open and close. When an aeroplane gains altitude, the pressure in the cabin goes down. The Eustachian tube can open to allow air out of your middle ear to equalise the pressure, and when it does so your ears 'pop'. The reverse happens when an aeroplane comes in to land. You can sometimes make your ears 'pop' by chewing or yawning.

Other observations that the particle theory can explain are expansion and contraction. This is not covered formally in this unit and will be met elsewhere (including Unit 8I).

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7Ga
Solids, liquids and gases

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
Materials exist in three different states of matter.	Identify examples of [solids, liquids, gases]. Recall the three states of matter.	Describe what the three states of matter are like.	Group materials using their states of matter.	Identify materials that are difficult to identify as [solids, liquids, gases].	Decide whether it is good to make a certain item out of a [solid, liquid, gas].	
All matter consists of particles, and particles are arranged differently in solids, liquids and gases. This idea can help explain their properties.	Describe the three states of matter in terms of [shape, volume, compressibility]. Recognise that all matter consists of particles. State the meaning of: vacuum, particle.	Identify a [solid, liquid or gas] from the arrangement of particles.	Draw the arrangement of particles in a [solid, liquid and gas]. Use the particle model of matter to explain the [squashiness/ compressibility, ability to flow, ability to change shape] of [solids, liquids, gases].	Compare different models of particles in [solids, liquids and gases].	Evaluate how well the particle model works to explain the properties of mixtures.	Design a model of a [solid, liquid or gas].

Objectives
Developing:

1. Classify materials as solids, liquids and gases.
2. Record observations and describe simple properties of the three states of matter.
3. State what is meant by volume.
4. Appreciate that the properties of waste materials determine their disposal.

Securing:

5. Describe the properties of the three states of matter in terms of shape, volume and compressibility.
6. Explain what a landfill site is and some of the problems they cause.

Exceeding:

7. Appreciate that some substances are difficult to categorise.

Focused Literacy & Communication Objectives
This topic provides an opportunity to focus on key Literacy & Communication skills:

1. Identify adjectives, comparatives and superlatives in sentences.
2. Use adjectives, comparatives and superlatives to measure and compare.

Student materials

STARTERS

1: Quick Quiz
Developing/Securing/Exceeding
BA
Use the 7G Quick Quiz for baseline assessment. Students can use the 7G Quick Quiz Answer Sheet to record their answers. You could use all of the Quick Quiz as a starter for the whole unit, and then again at the end of the unit to show progress. Or just use the first four questions, which relate to this topic. These questions could be revisited formatively in a plenary for this topic. See the ASP for more information about Quick Quizzes. Advice on dealing with any misconceptions highlighted by this activity can be found in the Background information.

Course resources
ASP: 7G Quick Quiz; 7G Quick Quiz Answer Sheet.

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2: Solids, liquids and gases

Securing

BA **WS**

The **AT** video *Dealing with waste* sets the context for the unit by providing ideas about waste management and solids, liquids and gases.

Introduce some statistics about the amount of waste we produce, explaining the role of landfill sites and how recycling is necessary. Include an introduction to how different waste materials in different states have to be handled differently because of their different properties.

Have a selection of solids, liquids and gases (which could be linked to waste) available. As a whole-class discussion, ask students how they would sort them into groups. As students will have met the terms solid, liquid and gas in KS2, they should have little difficulty in grouping the materials in this way. However, this will act as reinforcement and ensure that all students remember the terms. This activity will naturally lead into Exploring 1, where students observe the properties of solids, liquids and gases in more detail.

Course resources
AT: Video *Dealing with waste.*

Equipment
Selection of solids, liquids and gases.

3: Concept map

Securing

BA

The **AT** interactive *States of matter* asks students to select the correct words to describe the states of matter shown. This should recap terms met in KS2. You may then want to ask students to construct a concept map using terms such as solid, liquid, gas, ice, water and steam.

Although changes of state are not covered in detail in this unit, it may also be useful to ask them to include terms such as melt, evaporate, freeze and condense on their concept maps. The concept maps can be kept and revisited at the end of the topic, when students can add the properties of the three states of matter, and also at the end of the unit. See Plenary 4 and 7Ge Plenary 4.

Course resources
AT: Interactive *States of matter.*

4: Comparatives and superlatives

Securing

BA **Lit** **Prac** **WS**

Introduce words used to measure and compare in science. Start with a display of two beakers containing copper sulfate solution. Call them beaker X and beaker Y. One beaker could be larger than the other; one might be dirtier than the other one; etc. Ask students to write as many sentences as they can, comparing the two beakers in different ways. (You could use a range of different objects that can be compared, for example different rulers, measuring cylinders or fruits.) Then introduce a third beaker (much bigger or much smaller than the first two).

Discuss with the class how their sentences will change.

Equipment
Three beakers of copper sulfate solution: different sizes, different concentrations, different volumes, etc.

5: Comparatives and superlatives for waste

Securing

BA **Lit** **WS**

Hold a class discussion on words used to measure and compare when dealing with waste. Students could consider: type of materials, e.g. plastic/glass bottles or plastic/paper bags; size of objects in waste, e.g. biggest/most crushable/tallest/fattest; which one is better for the environment?; cost of material production; most/least expensive to produce. The **AT** interactive *Comparisons* asks students to label pictures using adjectives, comparatives or superlatives to compare masses and times.

Alternatively link to the time for waste to break down, e.g. apple cores and banana skins. Then write sentences comparing the processes, for example, ‘The apple core breaks down faster than the banana skin’. Then introduce other types of rubbish and ask students to estimate how long they would take to break down. Discuss how their sentences would change.

Some examples of other breakdown times: apple core (2 months); orange or banana peel (2 years); plastic bags (10–20 years); nylon fabric (30–40 years); leather (1–5 years); wool (1–5 years); paper bag (1 month).

Course resources
AT: Interactive *Comparisons.*

EXPLORING TASKS

1: Circus of observations

Developing/Securing

Prac **WS**

Provide a collection of solids, liquids and gases (detailed below) for students to examine, and record their findings on Worksheet 7Ga-2. Depending on

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student numbers, you may wish to set up two or three sets of identical stations.

Solids: include a range of solid materials, including a syringe with a piece of wood (or similar) inside it so students can attempt to squash it. If the syringe has a rubber end to the plunger it should be removed as it will be slightly compressible and may confuse students.

Liquids: provide several examples of liquids and some spare containers of various sizes so students can pour them from one container to another. Include a syringe with its end sealed, filled with coloured water.

Gases: include a syringe full of air – the end can be sealed, or students can seal the end themselves with a finger when attempting to compress the air (sealing the end prevents it being used for squirting water!). Also provide a large plastic bag full of air, tied tightly, for students to gently squash to observe the change of shape, and a bottle of dilute air freshener or perfume for students to observe that the gas spreads out. You may need to discuss with students the fact that some of the liquid evaporates, providing the smell.

Course resources
AP: Worksheet 7Ga-2.

Equipment (per station)
Solids: range of solid materials such as wooden block, iron (metal) block, rock, syringe with solid inside.

Liquids: range of liquids such as water, ethanol, cooking oil, assorted items of glassware (boiling tubes, small beakers, Petri dishes), syringe full of coloured water with sealed end.

Gases: syringe full of air with sealed end, large plastic bag full of air (tied tightly), open bottle of air freshener or perfume.

2: Classifying difficult substances
Securing
BA Prac **WS**
Provide a selection of substances that are difficult to classify, and ask students to decide if they are solids, liquids or gases, giving their reasons. The substances can be set out around the classroom, with students moving from one to another, or each group can be provided with their own samples.

⚠ Students must not be allowed to eat any of these samples.

Equipment (per group)
One sample of each of the following (if possible): rubber (an eraser will do), warm runny custard, cold set custard, jelly, sand, honey, toothpaste, tomato sauce, sugar, jam, modelling clay, foam rubber.

3: Different liquids with different properties
Securing
Lit Prac **WS**
Students time how long it takes a set volume of different liquids to go through a filter funnel (see list below). Ask each group to investigate one liquid, and share the results. A method should be agreed with students so that all groups obtain results that can be compared. This should also give an opportunity to practise adjectives, comparatives and superlatives, e.g. quick/quicker/quickest.

Developing: Give students instructions on what to do, which can be written on the board.

Securing: Students should be able to plan this simple experiment for themselves. The word viscosity need not be mentioned to students.

Exceeding: When planning the experiment, explain to students that they need to collect evidence that they can be sure of, which in turn will allow them to be more certain of their conclusions. Elicit the idea that repeated measurements are a good way of collecting evidence that they can be sure of.

⚠ Only use new liquids and wash hands after use.

Equipment (per group)
Filter funnel, clamp and stand, stop clock, thermometer, boiling tube, beaker, measuring cylinder, liquids to test, e.g. treacle, honey, water, milk, cream, new vegetable oil, washing-up liquid.

4: Change in viscosity with temperature
Securing/Exceeding
Prac **WS**
Students time how long it takes a set volume of vegetable oil at different temperatures to go through a filter funnel.

Developing: Show students the picture at the top of Worksheet 7Ga-7 and ask them to explain how they would do this experiment. Working with them, write step-by-step instructions on the board before allowing students to start work.

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Securing: Students should be able to plan this experiment for themselves. The word viscosity need not be mentioned to students.

Exceeding: When planning the experiment, explain to students that they need to collect evidence that they can be sure of, which in turn will allow them to be more certain of their conclusions. Elicit the idea that repeated measurements are a good way of collecting evidence that they can be sure of.

⚠ Avoid contact with the skin. Students should not be allowed to heat oil using a Bunsen burner, even with eye protection. The use of a water bath prevents the formation of pockets of gas, which eject the hot liquid as they rise to the surface. However, this may mean that forward planning is required and students could be recommended to start with the higher temperatures first – the vegetable oil can be cooled quite easily by standing it in a trough of iced water.

Course resources
AP: Worksheet 7Ga-7.

Equipment (per group)
Filter funnel, clamp and stand, stop clock, thermometer, boiling tube, beaker, measuring cylinder, vegetable oil, access to water bath(s) at pre-set temperatures agreed with students (max 50 °C), or access to plastic bowls and supplies of hot water to make own water baths, iced water.

5: Classifying materials
Securing
WS
Worksheet 7Ga-3 provides a set of cards that students can use as the basis for a discussion, including straightforward and difficult materials. The reasoning behind students' classification of the various substances is more important than the 'answers' they reach. This can be followed up by using Worksheet 7Ga-6 as discussion material.

Course resources
AP: Worksheets 7Ga-3; 7Ga-6.

6: A lot of waste
Securing
WS
Worksheet 7Ga-4 provides data about the amount of waste produced in different countries in different ways. Students are asked to discuss the different ways of recording data in order to draw conclusions. Students may not be familiar with the decimal notation for millions shown in the sheet and it is worth explaining this beforehand. Also, explain that you can add decimal numbers of millions to get an answer in decimal numbers of millions. This can be followed up by using Worksheet 7Ga-8 and Exploring 7 as further discussion material.

Course resources
AP: Worksheets 7Ga-4; 7Ga-8.

7: Measuring and comparing
Securing
BA **Lit** **WS**
At first there may seem to be some patterns to the formation of comparatives and superlatives.

Type of adjective	For comparative	For superlative	Example
one-syllable adjectives ending in a vowel	add '–er'	add '–est'	large, larger, largest
one-syllable adjectives ending in a consonant	double last letter and add '–er'	double last letter and add '–est'	hot, hotter, hottest
one-syllable adjectives ending in 'y'	change 'y' to 'i' and add '–er'	change 'y' to 'i' and add '–est'	happy, happier, happiest
two-syllable or more adjectives (not ending in a 'y')	use 'more'	use 'most'	acidic, more acidic, most acidic

But there are many exceptions to all of the rules. For example: good, better, best; bad, worse, worst; far, further, furthest; old, older, oldest; many, more, most.

Worksheet 7Ga-9 is a class worksheet which introduces ideas about adjectives, comparatives and superlatives. You may want to use the **AT** presentation *Making comparisons*, where students can explore comparative and superlative adjectives

Course resources
AP: Worksheet 7Ga-9.
AT: Presentation Making comparisons.

EXPLAINING TASKS

1: 7Ga Sorting rubbish (Student Book spread)
Developing/Securing/Exceeding
Questions 1 and 2 can be used as baseline assessment.

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The AT video *Dealing with waste* introduces some ideas about waste management and the properties of solids, liquids and gases (Starter 2).

Developing: Show students the video and then go through the last paragraph with them. Point out that photo A shows a landfill site.

Course resources
AT: Video *Dealing with waste.*

2: Waste categories
Securing
Prac WS
Empty out the contents of your bin (providing it is safe to do so) and sort the contents into groups. Ask students why we do not throw liquids into bins. Explain that this is for a number of reasons: it is difficult to take bins that are full of liquid to be emptied; they could make some of the paper unrecyclable; liquids such as paints cause problems in bin lorries because they can leak paint all over the road. Ascertain how much of your bin's contents could be recycled. Link this to recycling in your school. Tell students that councils with the highest recycling rates are achieving over 40% of all rubbish recycled.

Securing: Ask students to draw a pie chart of the contents of the bin using a spreadsheet.

Equipment
A bin full of (non-smelly) rubbish.

3: 7Ga Solids, liquids and gases (Student Book)
Developing/Securing/Exceeding
Introduce ideas about the different properties of the three states of matter and how the different states can be identified.

Student Book Questions 1, 2 and 3 can be used as baseline assessment for the topic.

Worksheet 7Ga-1 is the Access Sheet.

Course resources
AP: Worksheet 7Ga-1.

4: 7Ga Making comparisons (Student Book)
Developing/Securing/Exceeding
Lit WS
Allows students the opportunity to think about the use of adjectives, comparatives and superlatives to measure and compare. Question 1 can be used as baseline assessment.

Worksheet 7Ga-9 provides a resource for practising comparatives and superlatives.

Course resources
AP: Worksheet 7Ga-9.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check Literacy
Developing/Securing/Exceeding
FA Lit WS
Assessment: Students complete the Quick Check Literacy sheet for this topic, which includes some examples of the use of adjectives, comparatives and superlatives.

Feedback: Students check their answers in groups, correcting any mistakes.

Action: While teaching the next topics look for opportunities to discuss the proper use of these adjectives.

Course resources
ASP: 7Ga Quick Check Literacy.

2: Quick Check
Developing/Securing/Exceeding
FA
Assessment: Students complete the Quick Check sheet for this topic, which consists of a series of properties cards. Ask students to work in pairs to put the cards into three groups of properties – the cards marked with the three states of matter are not placed at this time.

Feedback: Student pairs group together into fours and compare their piles, correcting any mistakes and labelling their piles with the states of matter. Ask groups to nominate the property they think was the most difficult to match to a state of matter.

Action: While teaching the next topic, repeat the association between the property/properties that students found the most difficult and the relevant state(s) of matter as reinforcement.

Course resources
ASP: 7Ga Quick Check.

3: Thinking about solids, liquids and gases
Securing
FA
Assessment:
Plus, Minus, Interesting: All solids should be squashable. (Possible answers: **Plus** – it would be

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easier to get things into tight spaces; **Minus** – it would be more difficult to walk as the ground would squash under your feet; **Interesting** – would there be less damage in a car accident if solids were *squashable*?)

Consider All Possibilities: A material is difficult to squash. (Possible answers: it is a solid or a liquid.)

Odd One Out: solid, liquid, gas. (Possible answers: solids are the only substances that cannot flow; gases are the only substances that can be compressed.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose the best answer from their group and consider why they think it is the best. Ask a spokesperson from each of a number of groups to read out the best answer chosen by their group. Identify any ideas that are missing and share them with the class. If understanding is poor then revise states of matter that affect them at the start of the next lesson.

The **AT** presentation *7Ga Thinking skills* can be used for this activity.

Course resources
AT: Presentation *7Ga Thinking skills.*

4: Concept map revisited
Securing
Students revisit their concept maps from Starter 3, adding to them and correcting them in a different colour. Things that should be added include properties of the three states of matter.

5: Properties summary
Securing
The **AT** video *Dealing with waste* includes ideas about waste management and solids, liquids and gases. You could show students the video without the sound and ask different groups to write voice-overs for the video to help describe the properties of solids, liquids and gases.

Course resources
AT: Video *Dealing with waste*.

6: Getting it right
Securing
Lit **WS**
Write a sentence with an incorrect use of a comparative or superlative. For example, 'The most big landfill site in Europe is Greengairs in Scotland.' Discuss how to correct the sentence and then ask students to write down an incorrect use of a comparative or superlative in a science context. Working in groups the students can then discuss and correct the sentences.

HOMEWORK TASKS

1: Summary of properties
Developing/Securing
Worksheet 7Ga-5 provides simple questions on the three states of matter.

Course resources
AP: Worksheet 7Ga-5.

2: Solid or liquid
Securing
Worksheet 7Ga-6 provides questions on solids and liquids that are difficult to categorise.

Course resources
AP: Worksheet 7Ga-6.

3: Oil leak
Securing/Exceeding
Worksheet 7Ga-7 provides results from an experiment into temperature and liquid viscosity to interpret. The word viscosity is not mentioned although you might encourage some students to do the Optional extra (Question 9) and find this out. Note also that this sheet asks students to draw a smooth curve through a set of points on a graph, which they may not be familiar with. Skills Sheet PD 6 may be useful.

Course resources
AP: Skills Sheet PD 6. Worksheet 7Ga-7.

4: A study of rubbish
Securing/Exceeding
Worksheet 7Ga-8 provides questions on different ways of displaying data. This requires students to have a working knowledge of pie charts and bar charts. Skills Sheets PD 3 and PD 7 may be useful.

Course resources
AP: Skills Sheets PD 3; PD 7. Worksheet 7Ga-8.

ActiveLearn
Four ActiveLearn exercises are available for this topic: Solids, liquids and gases 1; Solids, liquids and gases 2; States of matter; Adjectives.

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7Gb
Particles

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
All matter consists of particles, and particles are arranged differently in solids, liquids and gases. This idea can help explain their properties.	Describe the three states of matter in terms of [shape, volume, compressibility]. Recognise that all matter consists of particles. State the meaning of: vacuum, particle.	Identify a [solid, liquid or gas] from the arrangement of particles.	Draw the arrangement of particles in a [solid, liquid and gas]. Use the particle model of matter to explain the [squashiness/ compressibility, ability to flow, ability to change shape] of [solids, liquids, gases].	Compare different models of particles in [solids, liquids and gases].	Evaluate how well the particle model works to explain the properties of mixtures.	Design a model of a [solid, liquid or gas].

Objectives
Developing:

1. State that all materials are made from particles.
2. Describe, draw and recognise the arrangement of particles in solids, liquids and gases.

Securing:

3. Describe how the movement and spacing of the particles is different in solids, liquids and gases.
4. Use the particle theory to explain the properties of solids, liquids and gases.

Exceeding:

5. Use the particle model to explain other observations about matter.

Focused Working Scientifically Objectives
This topic provides an opportunity to focus on key Working Scientifically skills:

1. Describe different types of observations and data that can be used as evidence.
2. Identify scientific questions, hypotheses and predictions.
3. Describe how evidence and observations are used to develop a hypothesis into a theory.
4. Explain how evidence and observations support or do not support a certain theory.

Student materials

Topic notes

- The idea that matter is made up of particles is fundamental to understanding the simplest properties of matter. It will be easier for students to appreciate and apply this theory if they have a visual picture of the different states.

STARTERS

1: Properties of solids, liquids and gases
Securing
BA
Ask students to name some properties of solids, liquids and gases. Write their suggestions on the board or use Worksheet 7Ga-2 to record students' suggestions. (This worksheet can be made into an OHP transparency or used on an interactive white board from the AP.) Then ask students why the three states of matter have these properties. Explain that these questions are the same as a scientist would ask. Ask students for any ideas they have. Advice on dealing with any misconceptions highlighted by this activity can be found in the Background information. The **AT** interactive *Materials and particles* asks students to label pictures showing the arrangement of particles in solids, liquids and gases.

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Course resources
AP: Worksheet 7Ga-2.
AT: Interactive *Materials and particles.*

2: Thinking about materials
Securing
BA
Use some Odd One Out exercises to recap previous topics and get students thinking about the properties of solids, liquids and gases. Note that there is usually more than one possibility, and the important outcome is the student's justification of their decision.

Assessment:
Odd One Out: sand, stone, wood. (Possible answers: sand is the only solid that can flow (because it is in tiny pieces); wood is the only one that came from living things.)

Odd One Out: ice, water, stone. (Possible answers: stone, as ice and water are the same substances; ice is the only one that does not exist at room temperature.)

Odd One Out: water, honey, petrol, wood. (Possible answers: petrol because it cannot be found in nature; wood is the only solid.)

Feedback: Students answer the thinking skills questions in groups. In doing so they should revise ideas on states of matter.

Action: Ask students to choose the best answer from their group and consider why they think it is the best. Ask a spokesperson from each of a number of groups to read out the best answer chosen by their group. Identify any ideas that are missing and share them with the class. If understanding is poor then review ideas about solids, liquids and gases.

The **AT** presentation *7Gb Thinking skills* can be used for this activity.

Course resources
AT: Presentation *7Gb Thinking skills.*

3: Introducing hypotheses and theories
Securing
BA **WS**
Write the question 'Why are the three states of matter different?' on the board. Discuss this question and introduce ideas about scientific questions, hypotheses, predictions and testing. You could use the block flowchart of the scientific method from Skills Sheet SI 1 and ask students to fill it in with the correct words, revising material from Unit 7B. This could be done in groups or on the board by taking suggestions from the class. This will revise the concept of the scientific method, which is met on Student Book spread 7Ba The scientific method.

Developing: Give students the words to use.

Course resources
AP: Skills Sheet SI 1.

4: Using models
Securing
WS
Introduce the idea of a scientific model as anything which helps us understand the things we see around us. Models help us describe, explain or find out about something that is very complicated by simplifying it.

You could discuss the different types of model used: demonstrate some simple models (such as a car) and write a mathematical formula on the board. Ask students what these both have in common. Elicit the idea that they are both types of model.

You could use Skills Sheet SI 4 as a basis (although this sheet goes beyond what most students will have covered so far). Unit 7J has a Working Scientifically spread on using different types of models.

Introduce the idea that we could need a model to help us describe the three states of matter.

Course resources
AP: Skills Sheet SI 4.

EXPLORING TASKS

1: Observations and theories
Securing
WS
Worksheet 7Gb-4 can be used to do a card sort activity that is intended to help students to differentiate between observations and hypotheses, and to realise that hypotheses (and theories) may have to change in the light of new evidence.

Developing: Students divide the cards into observations (evidence) and hypotheses.

Securing: Students are given all the cards except the ones about Chris's sore throat, Ben's homework and the funny smell, and are then asked to produce their own hypothesis, with reasons, as to who took the sandwich. They can then be given the remaining cards and asked to reconsider their hypotheses.

No 'answer' has been provided. The intended answer is that Ben accidentally knocked over

Melissa's bag when he was in the classroom doing his science homework, and the sandwich fell behind the radiator. This explains Ben's presence in the classroom. Chris did not eat much at lunchtime because his sore throat had started to hurt. It is not important that students reach this conclusion but they should be encouraged to realise that hypotheses and theories may have to change in the light of new evidence.

Course resources
AP: Worksheet 7Gb-4.

2: Explaining matter
Securing/Exceeding
Prac **WS**
In this activity students try to explain observations on matter using various mixing experiments.

First they mix 25 cm^3 sand and 25 cm^3 peas and use their observations to explain the reduction in volumes. Then they mix 25 cm^3 water and 25 cm^3 methylated spirits and measure the total volume (usually about 47 cm^3) and use the results and conclusions to the first part to explain the second part.

If the experiments are carried out in the reverse order they can be used as discovery learning and this stimulates discussion. The mixtures of alcohol and water can be collected for use in other experiments. The first part can be demonstrated, however, to save resources. Worksheets 7Gb-2 and 7Gb-3 describe the two parts of this investigation.

Securing: Students would be expected to be able to link the two experiments to explain the observations using particle theory.

Exceeding: Students could reverse the order of the experiments and try to suggest an explanation using their understanding of particle theory, which can then be illustrated with the second experiment. Students could also be asked to plan, produce and carry out a class talk on the mixing experiments using presentation software, illustrations and the second experiment.

⚠ Methylated spirits (ethanol) is flammable and toxic. Handle carefully and keep away from any source of heat.

Course resources
AP: Worksheets 7Gb-2; 7Gb-3.

Equipment (per group)
Sand, peas, water, bottle of methylated spirits, 2 × 50 cm^3 measuring cylinders, eye protection.

3: Hypotheses about states of matter
Securing/Exceeding
FA **WS**
Ask students to suggest hypotheses to explain the properties of the three states of matter. This could link back to Starter 1. Students should share their ideas with the class or within groups and evaluate their ideas, and those of others, to see how well they explain the observations in this topic and in Topic 7Ga. The four photos from Student Book spread 7Gb Hypotheses and theories (showing squashing balloons, dilution, etc.) could be displayed and used to discuss ideas about matter.

4: Modelling particles with students
Developing/Securing/Exceeding
WS
This is a Visual Auditory Kinaesthetic thinking skills exercise. Once students have an understanding of what the particle theory is, ask them to come up with models to show the three states of matter using themselves as particles. You could ask each group to come up with a plan or let each group put on a 'show' but this will probably need to be done in the school hall.

An alternative approach is to place five or six responsible students at the front of the class and ask other members of the class to give directions to the 'particles' to produce a suitable model. One way of doing the model is for students to link arms when modelling a solid, and be asked not to move their feet. They may sway slightly, to model the vibration of atoms. When modelling a liquid, students should walk around and stay close enough to always be touching a couple of other students, but without linked arms. When modelling a gas they should be allowed to walk (not run) around the room.

EXPLAINING TASKS

1: 7Gb Hypotheses and theories (Student Book)
Developing/Securing/Exceeding
WS
Questions 1 and 4 can be used as baseline assessment. You could use Skills Sheets SI 1–SI 4 when looking at scientific method, questions, hypotheses, predictions and models.

The **AT** interactive *Scientific method* asks students to put the steps of a scientific investigation into the correct order. The **AT** link *Scientific method 2* allows you to turn the labels on and off on diagram B.

Course resources
AP: Skills Sheets SI 1; SI 2; SI 3; SI 4.
AT: Interactive *Scientific method.* Labels on/off *Scientific method 2.*

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2: Demonstrations

Securing/Exceeding

Prac **WS**

Demonstrate the phenomena shown in images D, E and F on Student Book spread 7Gb Particles and D and E on Student Book spread 7Gb Hypotheses and theories to confirm how particle theory explains observations.

- Show solids do not change shape but liquids do.
- Use syringes to demonstrate that gases are compressible whereas solids and liquids are not.
- Show successive dilutions of a coloured solute (e.g. orange squash or potassium manganate (VII)).
- Show potassium manganate (VII) dissolving and diffusing in water. You could also show the differences in dissolving/diffusion in hot and cold water.
- Demonstrate squashing balloons and/or blowing up a balloon until it bursts.

The ‘exploding can’ could be demonstrated safely by taking an old coffee tin (the square catering type with the tight-fitting metal lid). Seal the lid on tightly and then heat using a Bunsen burner. After a few minutes the lid should pop off. It is often not that dramatic but must be done behind a safety screen just in case.

⚠ Potassium manganate (VII) is oxidising and harmful, and will stain skin.

Equipment
Example of a solid, a liquid and a gas, three sealed syringes containing a solid, water and air, 10 small beakers or test tubes, orange squash, potassium manganate (VII), tweezers, large beaker, hot water, balloon, large empty coffee tin with close-fitting lid, Bunsen burner, safety screen.

3: 7Gb Particles (Student Book)

Developing/Securing/Exceeding

These pages introduce students to the idea of particles. Skills Sheet SC 2 may be useful if students question the m/s notation for speed in the fact box on the spread. Worksheet 7Gb-1 is the Access Sheet.

The **AT** animation *Solids, liquids and gases* shows particles in the three states of matter and links the arrangement of the particles to the properties of solids, liquids and gases. The **AT** interactive *Properties and particles* requires students to match descriptions of particles with each state of matter.

Course resources
AP: Worksheet 7Gb-1.
AT: Animation *Solids, liquids and gases.*
Interactive *Properties and particles.*

4: Modelling particles

Securing/Exceeding

Prac **WS**

These activities are an extension of Starter 4.

Put some marbles or peas into the arrangements of particles shown for solids, liquids and gases on Student Book spread 7Gb Particles. Use a tray with high sides so that the marbles/peas do not roll off. Tell students that a theory for why solids, liquids and gases have different properties is called the particle theory. Explain that all materials are made out of particles but solids, liquids and gases have different arrangements of these particles. Invite students to say which of the marble/pea arrangements they think corresponds to each state of matter, and why they think that. Or give students marbles/peas and ask them to arrange them how they would be arranged in a variety of named materials (e.g. steel, water, air).

Alternatively, use a vibration generator to show students how the particles move at three different speeds. With a big class it may be useful to use a video camera so that a large image of the generator can be shown on a screen.

Worksheet 7Gb-5 could be used to support students thinking about particle models of matter.

⚠ If students do this practical it will need good supervision to prevent peas/marbles from ending up all over the floor and providing a slip hazard.

Course resources
AP: Worksheet 7Gb-5.

Equipment
Marbles or peas (dried if students are to use them), tray with high sides (or shallow box), or a vibration generator. Optional: video camera, video screen.

Use a space-filling model (polystyrene spheres glued together) to demonstrate each of the properties of solids the students considered earlier. It does not flow, squash or change shape but it has a fixed shape and fixed volume, and is dense because of the close packing of the spheres (particles).

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Equipment
Model of a solid made from polystyrene spheres glued together (or similar). (Take care with the glue used as some glues will attract the polystyrene spheres, making the sticking process awkward.)

5: Particle models
Securing/Exceeding
WS
Create a class list for situations explained by the particle theory of matter: gases and liquids changing shape; gases spreading out; gases compressed; dilution.

Ask students to come up with other situations which could be explained by using particle theory. Worksheet 7Gb-7 could be used for some examples.

Course resources
AP: Worksheet 7Gb-7.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check WS
Developing/Securing/Exceeding
FA **WS**
Assessment: Students complete the Quick Check sheet for this topic, which involves describing the meaning of terms related to scientific method.

Feedback: Students work in pairs and compare their answers, correcting any mistakes.

Action: Ask pairs if there are any disagreements and discuss with them reasons for these differences.

Developing: Students are able to write a simple definition of all terms.

Securing: Students are able to write a full definition of all terms.

Course resources
ASP: 7Gb Quick Check WS.

2: Quick Check
Developing/Securing/Exceeding
FA
Assessment: Students complete the Quick Check sheet for this topic, which provides a set of true/false statements to help students revise the ideas from this topic.

Ask students to rank the statements as true or false.

Feedback: Students work in groups and compare their answers, correcting any mistakes. Using their corrected statements, students then decide whether the second statement of each pair explains the first.

Action: Ask groups if there are any disagreements and discuss with them reasons for these differences.

Developing: Students rank the statements as true or false, and correct any false statements.

Securing: Using their corrected statements, students then decide whether the second statement of each pair explains the first.

Course resources
ASP: 7Gb Quick Check.

3: Theory and practice
Securing/Exceeding
FA **WS**
Worksheet 7Gb-5 challenges students to check their understanding of terms used in their work on scientific method and particle theory. Students peer mark and comment on each other's work.

Course resources
AP: Worksheet 7Gb-5.

4: Voting on particles
Securing
FA
The **AT** spreadsheet link opens *Voting on particles*. Four questions are asked, each on a different page in the spreadsheet. Pose each question to the class and ask students to vote for each of the possible correct answers A–D. Type the number of votes into the cells next to each possible answer and bars will appear on the graph showing the total votes for each answer. Move on to the next page and the answer is displayed along with the bar on the graph for the correct answer.

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Course resources
AT: Spreadsheet *Voting on particles.*

5: Correcting misconceptions
Securing
WS
Assessment: Ask students to think of an incorrect idea, about particles, that they or somebody else held at the start of this topic. After writing the incorrect idea at the top of a sheet of paper, they then pass it on to the next student, who reads it and writes the correct view below it. The paper is passed on to a third student, who after reading both ideas writes down the part in the previous topic/lessons he or she thought best explained the idea.

Feedback: Some students read out their lists and there is class discussion on which areas of work were most difficult and what activities/resources helped their understanding. The feedback could lead on to discussion of the use of models.

Action: Students and teachers take note of any remaining misunderstandings. Teachers should also note the activities their students said were most effective and use this to inform their teaching in the next topic.

HOMEWORK TASKS

1: Applying theories to matter
Developing/Securing
Worksheet 7Gb-8 provides an opportunity to apply particle theory to aspects involved in waste management.

Course resources
AP: Worksheet 7Gb-8.

2: What's the matter?
Securing
Worksheet 7Gb-9 provides comprehension questions on early theories of matter.

Course resources
AP: Worksheet 7Gb-9.

3: Using ideas about particles
Exceeding
Worksheet 7Gb-10 challenges students to use information about particles to explain expansion, contraction, evaporation and melting.

Course resources
AP: Worksheet 7Gb-10.

ActiveLearn
Four ActiveLearn exercises are available for this topic: Particles; Particle theory; Exploring particle theory; Working Scientifically.

7Gc Brownian motion

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
The kinetic theory can be used to explain diffusion.	State what is meant by: diffusion. Recall some effects of diffusion.	Use the kinetic theory to explain diffusion in liquids and gases. Explain why diffusion is a physical change. Explain how Brownian motion supports the kinetic theory.	Calculate the speed of diffusion.	Use the kinetic theory to explain why diffusion is faster in some materials than in others. Link the speed of diffusion to the mass of the molecules.	Evaluate how well kinetic theory explains diffusion.	Carry out a calculation to determine the speed of diffusion. Use ideas of random motion to justify why diffusion is a physical change which is irreversible.
The kinetic theory can be used to explain the properties of solids, liquids and gases. It is up to you to decide if you want to introduce the term 'kinetic theory'.	State the meaning of: kinetic theory.	Describe how particles move in a [solid, liquid, gas] and how this changes with temperature.	Use the kinetic theory to explain [melting, boiling, condensing, freezing, why gases fill the volume of their container but solids and liquids do not].	Compare [melting points, boiling points] of materials and link them to the strength of the [bonds, attractions between particles].	Compare densities of materials and link them to the mass of the particles and how closely they pack together. Evaluate how well kinetic theory matches evidence.	Use secondary sources to outline the development of kinetic theory.

Objectives
Developing:

1. Describe Brownian motion.
2. State where Brownian motion can be observed.

Securing:

3. Explain how Brownian motion occurs, using particle theory.
4. Convert metres to nanometres and vice versa.

Exceeding:

5. Explain how evidence from Brownian motion is used to support the particle theory.

Student materials

Topic notes

- The idea that matter is made up of particles is fundamental to understanding the simplest properties of matter. It will be easier for students to appreciate and apply this theory if they have a visual picture of the different states.

STARTERS

1: Brownian motion
Securing
Students watch part of the AT video *Brownian motion* with no sound. They are then asked to think

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about and describe what they are seeing. This should be a brief introduction to what Brownian motion is – not what causes it.

Course resources
AT: Video *Brownian motion.*

2: Thinking about particles
Securing

Consider All Possibilities: A tiny speck floating on some water is seen to be moving slightly. What ideas could explain this movement? (Possible answers: it is being blown by the wind; someone is blowing on it; the speck is a tiny organism that is moving; water particles are bumping into it.)

At this stage the students would not be expected to come up with the last answer, but this exercise will get students to think about the material that is covered in the topic. The **AT** presentation *7Gc Thinking skills 1* can be used for this activity.

Course resources
AT: Presentation *7Gc Thinking skills 1.*

3: Scientific questions
Securing
Prac **WS**

Show students some undiluted orange squash in one glass and the same volume of a more diluted orange squash in another glass. Ask students to come up with a scientific question about the two glasses, a hypothesis, a prediction and a way of testing the hypothesis/prediction. Possible answers: Why does one squash appear paler than the other? The colour of the squash depends on the amount of water added. If I add water to the darker squash, then it will become paler. I would add water to the squash.

Show students dilution and remind them that the particle theory explains what is happening in terms of mixing particles of squash with particles of water. This explains why the two colours mix together rather than stay separate.

Equipment
Orange squash: diluted and undiluted in two separate glasses, water.

4: Old theories
Securing
WS

Read out a list of old theories, such as: maggots are created from meat; everything is made of different amounts of fire, water, earth and air; the Earth is at the centre of the Universe; aliens live on the Moon. Ask students what these all have in common and explain that they were theories – scientific ideas. They have all been tested scientifically but there is little or no evidence to support them.

EXPLORING TASKS

1: Incorrect hypotheses and theories
Securing/Exceeding
WS

Ask students to use books and/or the Internet to find out about scientific theories that have been shown to be incorrect. They should produce a list of hypotheses and theories together with a simple description of each.

Developing: Give students ideas for what hypotheses/theories to check and ask them to find out one thing about each one (e.g. when it was disproved, when people believed it, who proposed it, who disproved it). Ideas include the Earth at the centre of the Universe, no creatures on Earth ever becoming extinct, the speed of sound cannot be broken, organisms being created out of dead materials, an unfrozen sea being found at the North Pole, and diseases like malaria and cholera being caused by bad air.

Exceeding: Students record the evidence that was used to disprove the hypotheses/theories on their list.

Equipment
Internet/library access.

2: Modelling particles with students
Developing/Securing/Exceeding
WS

This is a Visual Auditory Kinesthetic thinking skills exercise. Once students have an understanding of what the particle theory is and how there is a possible link to Brownian motion, ask them to come up with a model to show how the particle theory can explain Brownian motion, but using themselves as particles. You could ask each group to come up with a plan or let each group put on a 'show' but this will probably need to be done in the school hall.

An alternative approach is to place five or six responsible students at the front of the class and ask other members of the class to give directions to the 'particles' to model a gas. They should be allowed to walk (not run) around the room bouncing off the sides like pool balls on a table. Some fairly large, but movable object, could then be introduced to represent the pollen or dust. A large cardboard box would do. When the students bump into this object it should move slightly in the opposite direction.

3: History of particle theory
Securing
WS

Explain to students that the particle theory of matter has been developed over many years and that it has been modified as new evidence has been collected. Then get students to do Worksheet 7Gc-3, which also requires Worksheet 7Gc-4. This helps to provide a historical perspective on the development of the particle theory as well as providing further reinforcement of the distinction between observations and theories.

Developing: Do not use Worksheet 7Gc-3 but simply ask students to order the cartoon cells on Worksheet 7Gc-4.

Course resources
AP: Worksheets 7Gc-3; 7Gc-4.

Equipment
Scissors, glue.

4: Measuring the very small
Securing/Exceeding
WS
Introduce ideas of units and scales as outlined in Skills Sheet SC 2. (Note °C is not an SI unit and joules, volts, pascals, watts, hertz and newtons are all derived units.) Then show students that 1 000 000 000 nm = 1 m and 1 000 000 nm = 1 mm. The **AT** presentation *Comparing sizes* could help with this.

Students then complete Worksheet 7Gc-5 to practise interconverting units including the nano-scale: metres to millimetres, micrometres and nanometres. Skills Sheets MS 4 and SC 2 may be useful to support students who struggle with decimal notation using a large number of decimal places.

Extend this activity by asking students to measure some objects and ask them to convert their measurements in metres and centimetres into millimetres, micrometres and nanometres. The **AT** interactive *Units of measurement* asks students to convert measurements and match the answers to the questions.

Course resources
AP: Skills Sheets MS 4; SC 2. Worksheet 7Gc-5.
AT: Interactive *Units of measurement.*
Presentation *Comparing sizes.*

EXPLAINING TASKS

1: Chalk dust
Securing
Prac **WS**
Puff a little chalk dust or talc into the beam of an overhead projector or slide projector in a darkened room. Students should be able to see random movements of the particles. Ask students why the chalk dust behaves in this way. Explain that it is because air particles are hitting the dust.

Equipment
Overhead projector or slide projector, chalk or talcum powder.

2: Brownian motion
Securing
To introduce this topic, the **AT** video *Brownian motion* shows and explains Brownian motion. Show students the video but stop at the indicated point and do not reveal the explanation. Students can then discuss the observation and try to suggest an explanation for what they saw happening. Then show the students the last part of the video, which explains Brownian motion using particle theory. The **AT** interactive *Movement showing Brownian motion* asks students to select the movement showing Brownian motion in particles of smoke. Use the **AT** interactive *Explaining Brownian motion* and ask students to explain Brownian motion by selecting what it shows evidence of in liquids and gases.

Course resources
AT: Interactives *Explaining Brownian motion*; *Movement showing Brownian motion.* Video *Brownian motion.*

3: Investigating Brownian motion
Securing
Prac **WS**
Set up a demonstration of Brownian motion using a smoke cell. There are a number of possible set-ups using projectors and video cameras linked to microscopes. An **AT** link allows you to turn the labels on and off on diagram B on Student Book spread 7Gc Brownian motion.

Course resources
AT: Labels on/off *Observing Brownian motion within air with specks of smoke.*

Equipment
Smoke cell with light source, microscope, video camera to fit microscope.

4: Random
Securing
WS
Write the word ‘Random’ on the board and ask students to think of words which are similar. These can be written on the board too. Use them to initiate a discussion on the nature of randomness. Ask students to think up some other random events or situations (e.g. tossing a coin, throwing a dice).

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Finally, ask students to work in groups, to think up a model of how they could use a dice or other item to instruct a student to make random movements. Link this idea to particle theory. If large dice are available their model could be tried out in class.

5: 7Gc Brownian motion (Student Book)

Developing/Securing/Exceeding

FA

This introduces Brownian motion as part of the evidence for the particle model. This also looks at the nano-scale. Skills Sheets MS 4 and SC 2 may be useful to support students who struggle with decimal notation using a large number of decimal places. Worksheet 7Gc-1 is the Access Sheet. Questions 1, 2 and 3 can be used for formative assessment.

The **AT** video *Brownian motion* shows how Brownian motion is produced and what it looks like. The **AT** animation link opens *Brownian motion in practice*. You could also look for Brownian motion videos on the Internet, but be aware that not every video labelled as 'Brownian motion' is actually Brownian motion!

Course resources
AP: Skills Sheets MS 4; SC 2. Worksheet 7Gc-1.
AT: Animation *Brownian motion in practice*.
Video *Brownian motion.*

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check

Developing/Securing/Exceeding

SA **WS**

The 7Gc Quick Check sheet provides practice for students in considering observations, theories and predictions.

Assessment: Students complete the Quick Check sheet for this topic, which consists of a card sort. Students are asked to decide if a statement is an observation, a theory or a prediction. Ask students to explain their choices.

Feedback: Students in groups of four compare their choices, correcting any mistakes. They should then discuss which of the observations, theories and predictions they think are correct. A spokesperson for each group is nominated to report on any points that caused problems or were areas of disagreement during the group's discussion.

Action: All students write down at least one thing they have learned, or improved their understanding of, by carrying out the exercise.

Course resources
ASP: 7Gc Quick Check.

2: Beg of my neighbour

Securing

FA **WS**

Assessment: Ask each student to write down three things that they think the person sitting next to them should have learnt and when they would have learnt each thing. Then ask students to ask each other in pairs whether they agree on the things they should have learnt. Ask them to agree a final list of the three most important points.

Feedback: Display a simple set of learning outcomes for the topic. For example, you should be able to:

- state what is meant by Brownian motion
- describe how the particle theory can explain Brownian motion
- explain how Brownian motion supported the particle theory of matter
- convert metres to nanometres and vice versa
- explain how scientists use hypotheses and theories to explain observations.

Action: Ask each pair if there are any additions that should be made to the list. Students then complete their list of 'Things I should have learned'.

3: Q & A Brownian motion

Securing/Exceeding

FA

Ask each student to write down a question about something from Topics 7Gb and 7Gc. They should write the question on the left of a strip of paper and the answer on the right and then tear the strip in half. Appoint a student to collect all the questions and another to collect all the answers. Once collected, hand out the questions and answers so that each student gets one question and one answer. Then get a selected student to read out his/her question. The student with the right answer then stands up and reads out the answer. You may need to restart this activity if the original answers to questions are wrong. Do not identify individuals who have made these mistakes; they will learn from any discussion as to what the answer should be.

Equipment
Strips of paper.

4: Thinking about theories

Securing

WS

Assessment:
Odd One Out: the Sun and Moon circle the Earth, Rajesh will go shopping tomorrow, all things can

exist in one of three states, shadows are formed when light cannot pass through something. (Possible answers: 'the Sun and Moon circle the Earth' has been disproved; 'Rajesh …' is a prediction whereas the others are theories.)

Consider All Possibilities: Solid gold turns into liquid gold when it is heated up. What theories could explain this? (Possible answers: solids are made of boxes that break open releasing liquids when heated; solids are made of tiny parts that break away from each other when heated; solids are composed of many tiny solid parts, all of which become fluid.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another.

Action: Ask students to choose the best answer from their group and consider why they think it is the best. Ask a spokesperson from each of a number of groups to read out the best answer chosen by their group. Identify any ideas that are missing and share them with the class. If understanding is poor then revise states of matter that affect them at the start of the next lesson.

The **AT** presentation *7Gc Thinking skills 2* can be used for this activity.

Course resources
AT: Presentation *7Gc Thinking skills 2.*

HOMEWORK TASKS

1: Brownian motion and the scientific method
Developing/Securing

WS

Worksheet 7Gc-6 provides further opportunity to consider the scientific method in relation to Brownian motion and the particle theory of matter.

Course resources
AP: Worksheet 7Gc-6.

2: Measuring movements
Securing/Exceeding

WS

Worksheet 7Gc-7 provides practice in measurement and calculations in the context of Brownian motion.

Course resources
AP: Worksheet 7Gc-7.

3: Sock theories
Securing/Exceeding

WS

Worksheet 7Gc-8 provides comprehension questions on what makes a good scientific theory.

Course resources
AP: Worksheet 7Gc-8.

ActiveLearn
Three ActiveLearn exercises are available for this topic: Brownian motion 1; Brownian motion 2; Brownian motion 3.

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7Gd Diffusion

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
The kinetic theory can be used to explain diffusion.	State what is meant by: diffusion. Recall some effects of diffusion.	Use the kinetic theory to explain diffusion in liquids and gases. Explain why diffusion is a physical change. Explain how Brownian motion supports the kinetic theory.	Calculate the speed of diffusion.	Use the kinetic theory to explain why diffusion is faster in some materials than in others. Link the speed of diffusion to the mass of the molecules.	Evaluate how well kinetic theory explains diffusion.	Carry out a calculation to determine the speed of diffusion. Use ideas of random motion to justify why diffusion is a physical change which is irreversible.

Objectives

Developing:

1. Describe diffusion as the movement of one substance through another without any external mixing.
2. Recall some everyday examples of diffusion.
3. Make a prediction about diffusion.

Securing:

4. Explain how diffusion occurs in terms of movement of particles.
5. Explain why the speed of diffusion in gases is faster than in liquids.
6. Recognise examples of diffusion causing problems.

Exceeding:

7. Carry out a calculation to work out the speed of diffusion.

Student materials

Topic notes

- The idea that matter is made up of particles is fundamental to understanding the simplest properties of matter. It will be easier for students to appreciate and apply this theory if they have a visual picture of the different states.

STARTERS

1: Model students

Securing

Ask students to write a brief description of what happened to them as they came into the room. They should include the situation outside the room, how they came through the door and where they went in the room. Collect in the descriptions for later use. Then tell students that this is a model for something (but say no more than that) and that you will look at their descriptions later (in Plenary 4).

2: Word meanings

Securing

BA **Lit** **WS**

Write these words on the board: diffusion, dissolving, digestion, distillation, data. Ask students what they all have in common. (They all begin with d; they are all scientific words; they all contain vowels and consonants; they each contain at least two letters which are the same.) Then ask students what each of the words mean. Allow groups to discuss the meanings for a few minutes to agree on what they think. Then ask a spokesperson from each group to give the definition of one word and an idea of how certain they are of the answer (on a scale of 1 to 5, with 1 being absolutely certain). For words that have scored low on the Certainty of Response Index scale (see Introduction) and have been poorly defined, ask students how they would find out the meanings of the words. Suggestions should include asking a teacher, looking the words up in the glossary at the back of the textbook, looking in a dictionary. Encourage students to do one of these things whenever they encounter words that they do not know or cannot remember the meanings.

3: Diffusion

Securing

Prac **WS**

Have a container of a strong-smelling substance placed in the room just before the students enter. It is useful if this can be placed in an area in which the entry of the students is not going to cause air currents. Some students may comment on the smell, and others may also notice that the smell has not reached all areas of the room. Discuss the reasons for this and introduce the term 'diffusion'. Ethanol, perfume and after-shave are suitable substances.

⚠ Ethanol is highly flammable. Avoid naked flames.

Equipment
Dish of strong-smelling substance, e.g. ethanol, perfume or after-shave.

EXPLORING TASKS

1: Diffusion of smells

Developing/Securing

Prac **WS**

Hold a class discussion of how you could measure the rate of diffusion of a gas. You could use a bottle containing something smelly, e.g. perfume, to test students' ideas.

Developing: At its simplest, this could just be an activity where members of the class put their hands up as soon as they can smell a perfume that has been placed in a dish at the front of the room. This would be sufficient to establish that the smell spreads out around the room.

Securing: A slightly higher level of sophistication might be to have a prepared map of the classroom, with students filling in the rank order of the places where the smell could be detected after the start of the experiment. This is likely to show that while the general trend is for the particles to move outwards from the centre, this motion is not necessarily uniform. This option is an example of an experiment where it is not easy to control any variables, but which may nevertheless yield useful, semi-quantitative data.

Exceeding: You could assemble a number of students at different, known distances from the perfume. Each student would be given a stop clock and told to stop it as soon as he or she noticed the smell. Results can be tabulated and a scatter graph of distance against time can be drawn. The gradient of the graph will be an estimate of the speed of diffusion. This is a good opportunity to practise skills of planning the number and range of measurements to be taken, and of drawing lines of best fit through data that is likely to have quite a large scatter.

⚠ If using a chemical from the prep room, consult safety documentation to ensure that it is not hazardous to breathe!

Equipment
Developing: small, screw-top bottle containing cotton wool impregnated with a perfume or other strong-smelling liquid.

Securing: as Developing plus overhead transparency of map of classroom, plus copies for students.

Exceeding: as Developing plus stop clocks, measuring tape.

2: Observing diffusion in liquids

Developing/Securing

Prac **WS**

Start by placing a strongly coloured water-soluble substance into a glass of water, in a glass of water (e.g. a spoonful of meat extract or yeast extract, a teabag, some food colouring with a small dropper). Students can record their results in written or diagrammatic form. This practical can be used to carry out a Working Scientifically investigation. A set of assessment descriptions is provided in the ASP.

Developing: Worksheet 7Gd-2 supports this activity.

Securing: Worksheet 7Gd-3 supports this activity and involves some aspects of planning and more quantitative measurements (how high the colour has spread in the glass after various time intervals) and repeating the experiment with water at different temperatures.

Exceeding: Carry out the investigation given in the first part of Worksheet 7Gd-3, up to and including the apparatus list. This means that students have the opportunity to do all the planning of the method for the investigation.

⚠ Water from a kettle should not be boiling and should be dispensed by a teacher or assistant.

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Course resources
AP: Worksheets 7Gd-2; 7Gd-3.
ASP: 7G WS Investigations.

Equipment (per group)
250 cm^3 beaker, water, something that dissolves in water with a strong colour (e.g. a spoonful of meat extract or yeast extract, a teabag, some food colouring with a small dropper), stop clock, thermometer, ruler, access to kettle.

3: Diffusion of hydrogen chloride and ammonia
Securing/Exceeding
Prac **WS**

This is a teacher demonstration of the 'traditional' experiment investigating the diffusion of hydrogen chloride and ammonia gases. All stages of this demonstration should be carried out in a fume cupboard.

Step 1 Open the bottle of ammonia solution carefully, pointing the bottle away from everyone. Open the bottle of hydrochloric acid and hold the stopper near the mouth of the ammonia bottle. Students should see white clouds of ammonium chloride form.

Step 2 Clamp the glass tube at either end, making sure it is horizontal.

Step 3 Moisten one of the cotton wool wads in the mouth of the ammonia bottle. Push the soaked end into one end of the glass tube. Replace the lid on the bottle.

Step 4 Quickly repeat this procedure with a second wad of cotton wool and the hydrochloric acid. Put the cotton wool wad into the other end of the glass tube.

Step 5 Push bungs into the ends of the glass tube to reduce the quantity of the gases which escape Once assembled, the tube can be removed from the fume cupboard.

Step 6 Watch the tube and observe a ring of white powder forming near the middle of the tube. This is ammonium chloride.

Note: The tube used must be clean and completely dry for this experiment.

Worksheet 7Gd-4 sets the scene and asks students to make a prediction of where the white 'smoke ring' will occur. Typical results give the formation of ammonium chloride about one-third of the way along the tube from the hydrogen chloride end.

The reaction taking place is:
$NH_3\ (g) + HCl\ (g) \rightarrow NH_4Cl\ (s)$

The time taken for the ring to form will depend on the dimensions of the tube, the amount of the solutions which are put on the cotton wool wads and the temperature of the room. The ring usually forms nearer to the hydrochloric acid end of the tube as hydrogen chloride diffuses more slowly than ammonia. This is because hydrogen chloride has almost twice the molecular weight of ammonia, and the rate of diffusion is inversely proportional to the square root of the molecular mass of the gas.

It is worth noting that the rate of diffusion is not the same as the speed at which the gas molecules travel (which is hundreds of metres per second). The gas molecules follow a zig-zag path through the tube as they collide with the air molecules in the tube.

Concentrated hydrochloric acid is a corrosive solution that releases a corrosive and toxic gas (hydrogen chloride). Concentrated ammonia is a corrosive solution that releases a toxic gas. This demonstration should only be carried out by a teacher in a well-ventilated laboratory. The cotton wool should be handled with tongs or tweezers, and the release of any fumes into the laboratory should be kept to a minimum. The 'prepared' method suggested reduces the risk to students even further. All solutions can then be handled in the prep room in a fume cupboard.

Course resources
AP: Worksheet 7Gd-4.

Equipment
2 stands and clamps, glass tube about 0.5 m long and 2 cm inside diameter (dimensions not critical), bungs to fit into the ends of the glass tube, cotton wool, tweezers/forceps, conc. hydrochloric acid, conc. ammonia solution (alternatively, cotton wool impregnated with each solution can be prepared and stored in a small, stoppered container that will fit inside the glass tube), eye protection, protective gloves.

4: Landfill diffusion
Securing
Prac **WS**

Ask students to think about the problems which could be caused by diffusion at landfill sites.

Introduce the investigation into the rates of diffusion depending on the type of soil. Give the students an

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introduction to the resources available, and some hints at the set-up.

Working in groups students should then plan the investigation, producing a written aim and method. After the teacher has checked the plans, the students can carry out their investigation and complete their write-up with results, conclusion and evaluation.

The simplest set-up would involve placing a coloured sweet into a white powdered solid to represent the soil, e.g. rice, flour, dry white sand. (The rice would have the largest spaces and represent the coarsest soil while the flour would have the smallest spaces and represent the finest soil. The sand would be somewhere in between.) The students should then carefully pour a measured volume of water over the sweet (about 5 cm^3) and observe how quickly the colour spreads.

The results should show that diffusion is fastest with the coarsest grains (the rice).

The results and the consequences for the diffusion of pollution could then be discussed by the class.

⚠ Safely dispose of materials immediately after use. Students should not eat the sweets.

Equipment (per group)
Petri dishes, 10 cm^3 measuring cylinder, water, solid with strong soluble colour, rice, flour, dry white sand, stop clock.

5: Modelling diffusion
Securing/Exceeding
FA
Worksheets 7Gd-5 and 7Gd-6 can be used by individual students or groups to describe a model to explain what is happening during diffusion.

Developing: Use Worksheets 7Gd-5 and 7Gd-6 to support this activity.

Securing: Use only Worksheet 7Gd-6 to support this activity.

This task can be reviewed as Plenary 4 so that students can get a sense of how their understanding has improved over the course of this topic.

Exceeding: Use Worksheet 7Gd-7 to investigate a different way of calculating diffusion rates.

Course resources
AP: Worksheets 7Gd-5; 7Gd-6; 7Gd-7.

EXPLAINING TASKS

1: 7Gd Diffusion (Student Book)
Developing/Securing/Exceeding
FA
Questions 1 and 3 can be used for formative assessment for the topic. Worksheet 7Gd-1 is the Access Sheet.

The **AT** animation *Diffusion and the particle model* shows animated versions of diffusion in liquids and gases. After showing students this animation, the **AT** interactive *Diffusion* asks students to sort the states of matter into order according to the speed at which their particles diffuse.

Course resources
AP: Worksheet 7Gd-1.
AT: Animation *Diffusion and the particle model.* Interactive *Diffusion.*

2: Demonstration of diffusion
Securing/Exceeding
Prac **WS**
Find the volume of a gas jar by filling with water and emptying it into measuring cylinder. Thoroughly dry the gas jar and place 1–2 g of copper turnings in the bottom. Add 0.8 cm^3 of concentrated nitric acid per 100 cm^3 of gas jar volume and place a greased lid on the jar. The reaction produces nitrogen dioxide gas that, if the correct volume of acid has been used, will just fill the jar. Explain why the gas spreads throughout the jar using the idea of particles.

Securing: Ask students to compare the speed of diffusion in this task with that shown in the animation in Explaining 1. Ask them to account for this difference in speed.

⚠ This demonstration must be done in a fume cupboard and goggles must be worn. Nitrogen dioxide is toxic and corrosive.

Concentrated nitric acid is oxidising and corrosive and is best handled with chemically resistant gloves.

Equipment
Fume cupboard, measuring cylinder, 1–2 g copper turnings, concentrated nitric acid, greased gas jar with lid, eye protection (goggles).

3: Liquid diffusion
Securing
Prac **WS**
Prepare two beakers of potassium manganate (VII) in

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water in advance. The first will have a few crystals of potassium manganate (VII) dissolved and dispersed throughout, the second will have a few crystals of potassium manganate (VII) placed at the bottom of the beaker of water and left for approximately 15 minutes, to allow the colour to spread through half the beaker. A third beaker should be set up as the practical is introduced to students with the same amount of potassium manganate (VII) placed at the bottom of the beaker of water.

Explain to students how the apparatus has been set up and ask them to explain what they see.

Developing: Explain that the purple substance dissolves in water, and the dissolved substance then spreads out through the water in a process called diffusion. Point out that the water is not being stirred or moved in any way.

Securing: Explain that the purple substance dissolves in water, and the dissolved particles of the substance then diffuse through the water particles. Ask students to compare the speed of diffusion in this task with that shown in Explaining 2. Ask them to account for this difference in speed.

Equipment
3 beakers, water, potassium manganate (VII).

4: Modelling diffusion
Securing
Prac WS
This is similar to Explaining 4 in Topic 7Gb. Put some marbles or peas into the arrangements of particles shown for liquids and/or gases on Student Book spread 7Gb Particles. Use a tray with high sides so that the marbles/peas do not fall off. Next add marbles/peas of a different colour to one side of the tray. Now shake the tray so that the marbles/peas move and the differently coloured marbles/peas will be seen to diffuse into the others. Use the model to illustrate why diffusion in liquids takes longer than diffusion in gases.

Equipment
Marbles or peas (dried if students are to use them) of two different colours, tray with high sides (or shallow box).

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Quick Check
Developing/Securing/Exceeding
FA
Assessment: The 7Gd Quick Check sheet provides a set of simple questions about diffusion and particles. The answers to the questions are found on a wordsearch grid and a mystery word is asked for.

Feedback: Ask students to confer with one another in order to check their work and see who has found the mystery word.

Action: Then review the answers to the questions with the class. Students should note where they were wrong and explain the correct answers.

Course resources
ASP: 7Gd Quick Check.

2: Thinking about diffusion
Securing
FA WS
Assessment: Ask students to consider these two Consider All Possibilities statements. As with activities of this type, it is not the answer that matters but the justifications that students use for their answers.

Consider All Possibilities: You can hear someone cooking food but cannot smell it. (Possible answers: the food being cooked does not smell; you have a cold and so cannot smell anything; there is a breeze moving the smell away from you; the smell has not had time to diffuse as far as you yet.)

Consider All Possibilities: Mike has placed an air freshener at one end of the room but he can not smell it at the other end of the room. (Possible answers: the air freshener does not work/has no smell; Mike can not smell things; the air freshener needs to have more time for its smell to spread; Mike has not opened the air freshener properly.)

Feedback: Students answer the thinking skills questions in groups, thereby feeding back their thoughts to one another and discussing the possibilities.

Action: Ask students to choose the best answer from their group that includes a scientific explanation of diffusion. They should also consider why they think it is the best. Ask a spokesperson from each of a number of groups to read out the best answer chosen by their group. Identify any ideas that are missing and share them with the class. If understanding is poor then revise particle theory at the start of the next lesson.

The AT presentation *7Gd Thinking skills* can be used for this activity.

Course resources
AT: Presentation *7Gd Thinking skills.*

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3: Topic question

Securing

SA Lit WS

Assessment: Ask students to write an answer to the sub-headed question at the start of the section: 'Why do some things spread out?' Instruct them that their answer should contain more diagrams than words.

Feedback: Students work in groups to check their answers. Ask students to grade each other's summaries for brevity, clarity and content. They should point out two ways it is good and one way it could be improved.

Action: Check students' review 'I can…' statements in the Student Book for Topic 7Gd to see if they were all covered.

4: Model students – revisited

Securing/Exceeding

WS

Review Exploring 5, working in pairs or small groups. Students comment on each other's use of Worksheets 7Gd-6 and 7Gd-7 to see how their understanding of diffusion has improved.

If the students have completed Starter 1, return the descriptive paragraph to each student. Working in groups students then discuss each other's paragraphs and try to find an answer to the question: What are students coming into the room a model for? Through discussion try to elicit the ideas that the students were in higher concentration outside the door (or in the doorway or corridor) and as they came into the room there was more space and students were in much lower concentration and so they spread out, just like the diffusion of a gas.

This should end with a class discussion on the value of this model of diffusion. In what ways is it a good model? In what ways is it a poor model? How could we improve the model?

HOMEWORK TASKS

1: A rubbish problem

Developing/Securing

Worksheet 7Gd-8 provides straightforward questions on diffusion.

Course resources
AP: Worksheet 7Gd-8.

2: Thinking about diffusion

Developing/Securing/Exceeding

Worksheet 7Gd-9 provides questions on the movement of particles in liquids and solids.

Course resources
AP: Worksheet 7Gd-9.

3: Random motion

Exceeding

Worksheet 7Gd-10 provides more challenging questions on the random movement of particles in a gas.

Course resources
AP: Worksheet 7Gd-10.

ActiveLearn

Three ActiveLearn exercises are available for this topic: Diffusion; Particles and diffusion; Speed of diffusion.

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7Ge
Air pressure

This grid shows the basic concepts met in this topic, together with a scheme of cognitive progression for each concept. Opportunities to cover learning and progression are given. Working Scientifically concepts are integrated throughout the materials.

Conceptual statement	Cognitive progress					
	Remembering (a)	Understanding (b)	Applying (c)	Analysing (d)	Evaluating (e)	Synthesising & creating (f)
The kinetic theory can be used to explain the pressure of gases.	State what is meant by gas pressure. Recall some effects of gas pressure.	Use the kinetic theory to describe the cause of gas pressure. Describe how the pressure of gases in containers can be [increased, decreased].	Use the kinetic theory to explain why gas pressure [increases, decreases] with [temperature, number of particles, volume].	Identify correlations by analysis of graphs of [pressure, volume, temperature].		Identify relationships showing direct and inverse proportion by analysis of graphs of [pressure, volume, temperature]. Develop a model to illustrate gas equations.
All matter consists of particles, and particles are arranged differently in solids, liquids and gases. This idea can help explain their properties.	Describe the three states of matter in terms of [shape, volume, compressibility]. Recognise that all matter consists of particles. State the meaning of: vacuum, particle.	Identify a [solid, liquid or gas] from the arrangement of particles.	Draw the arrangement of particles in a [solid, liquid and gas]. Use the particle model of matter to explain the [squashiness/ compressibility, ability to flow, ability to change shape] of [solids, liquids, gases].	Compare different models of particles in [solids, liquids and gases].	Evaluate how well the particle model works to explain the properties of mixtures.	Design a model of a [solid, liquid or gas].

Objectives

Developing:

1. Describe how moving gas particles cause pressure when they hit the walls of their container.
2. Recognise some effects of pressure (e.g. blowing up a balloon).
3. Explain that more particles in a container will cause a greater pressure.

Securing:

4. Explain the ways in which gas pressure can be increased (more particles introduced into a container, container is made smaller, gas is heated).
5. Describe what a vacuum is.
6. Explain some of the effects of air pressure (e.g. using a straw, collapsing can).

Exceeding:

7. Explain how barometers work.

Student materials

Topic notes

- The idea that matter is made up of particles is fundamental to understanding the simplest properties of matter. It will be easier for students to appreciate and apply this theory if they have a visual picture of the particles in gases.

Be prepared:
Starter 2: Magdeburg hemispheres.
Plenary 3: marshmallows.

STARTERS

1: Collapsing cans
Securing
Prac WS
First describe to the students the experiment you are about to demonstrate and ask them to write down what they think will happen. Then set up the collapsing can. Connect a vacuum pump to a sealed, empty can, or to an empty plastic drinks bottle. Observe what happens when most of the air is removed and ask students to explain what is happening. It does not matter if they cannot think of the correct explanation. Students may initially explain the collapsing can in terms of the vacuum pump sucking the sides in, as opposed to the air outside pushing the sides in.

The AT interactive *Different pressures* asks students to sort three cans filled with gas in order of increasing pressure.

Course resources
AT: Interactive *Different pressures.*

Equipment
Empty can or plastic drinks bottle, vacuum pump, bored cork/bung, glass tube.

2: Magdeburg hemispheres
Securing
Prac WS
This is particularly effective if the hemispheres have been prepared before the lesson. Ask a student to try to pull the two hemispheres apart. If you can then let air in without being observed, you can demonstrate that you can separate the spheres using just your little fingers, whereas the student could not separate them with their full strength. Again, this practical should be repeated later in the lesson when students should be able to explain what happens in terms of particles and air pressure.

Petroleum jelly smeared around the contact surfaces will help to ensure a good seal.

If you do not have any Magdeburg hemispheres there are some demonstrations available on the Internet.

Equipment
Magdeburg hemispheres, petroleum jelly, vacuum pump.

3: Gases under pressure
Securing
WS
The AT video *Gas pressure* shows some other effects of air and gas pressure which are possibly too dangerous or difficult to do in the school laboratory. The AT interactive *Changing pressure* asks students to select the ways in which gas pressure can be increased.

Course resources
AT: Interactive *Changing pressure.* Video *Gas pressure*.

4: Visualising pressure
Securing/Exceeding
WS
Discuss with students what it would feel like if they were out in a hail storm with small hail stones. Then ask them to say what it would feel like if more hail stones fell over the same time period. Elicit the idea that they would feel more pressure on their heads and link this to the idea of gas particles hitting the walls of a container.

EXPLORING TASKS

1: Syringes
Securing/Exceeding
Prac WS
Give students syringes, ask them to seal the end with a finger, and press in the plunger. Ask them how the force needed to press the plunger changes as it moves further in. Ask students to submit ideas as to why this happens and then discuss the ideas in groups, with each group then submitting a final idea to discuss as a class. Once the class has reached its decision, confirm the correct answer (the same number of particles is being forced into a smaller space, so they collide with the walls more often and the pressure increases).

Equipment (per group)
Syringes.

2: Things that rely on pressure
Developing/Securing
WS
The AT presentation *Things that rely on pressure* gives students the opportunity to explore gas pressure in various objects.

Course resources
AT: Presentation *Things that rely on pressure.*

3: Fly-tipping debate
Securing/Exceeding
Lit WS
There is an opportunity for a debate in the 'Have your say …' box on Student Book spread 7Ge Waste. Refer to Skills Sheet RC 5 for ideas on how to run a debate. Worksheet 7Ge-5 will help some students to formulate their views.

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It should be noted that the issue of fly-tipping is not as simple as it may seem. Whilst some fly-tippers are lazy householders who cannot be bothered to go to a household waste recycling centre, others are commercial house-clearers who are not allowed to use household waste recycling centres. (They are only for householders and are paid for by council tax.) Were they to take their rubbish to a landfill site they would be charged landfill tax. To avoid this tax, they fly-tip.

Course resources
AP: Skills Sheet RC 5. Worksheet 7Ge-5.

4: Pneumatic tyres
Securing
WS
Ask students to find out about Robert Thomson, John Dunlop and the development of the pneumatic tyre.

Developing: Ask students to find out what Robert Thomson and John Dunlop both invented and ask them to say whether they think things would be invented twice today, giving their reasons. Skills Sheets RC 1 and RC 2 may be useful for this activity.

Securing: Ask students to prepare presentations on the development of the pneumatic tyre. Be aware that images downloaded from the Internet may be under copyright.

Course resources
AP: Skills Sheets RC 1, RC 2.

Equipment
Internet/library access.

EXPLAINING TASKS

1: 7Ge Air pressure (Student Book)
Developing/Securing/Exceeding
FA **WS**
Questions 1 and 3 can be used for formative assessment. Worksheet 7Ge-1 is the Access Sheet and Worksheet 7Ge-2 is the *Developing* sheet. A helpful prop is a table tennis ball, which can be dropped or thrown to model a gas particle hitting the wall of its container.

The **AT** animation *Air pressure* explains how particles exert pressure.

Ask students to suggest some other uses or effects of pressure in gases. Suggestions may include car tyres, gas cylinders and popping ears on aeroplanes. There is more information on this in the Background information. An **AT** link allows you to turn the labels on and off on diagram A.

Course resources
AP: Worksheets 7Ge-1; 7Ge-2.
AT: Animation *Air pressure.* Labels on/off *The air pressure inside a car tyre.*

2: 7Ge Waste (Student Book)
Developing/Securing/Exceeding
WS
The **AT** interactive *Concept cartoon: Too full or not too full?* shows speech balloons discussing what happens to landfill in relation to the properties of the materials. The concept cartoon can be used to consolidate learning and as an opportunity for students to apply their understanding. Ask students to reflect on the cartoon individually before sharing their ideas in small group discussion. Class feedback could involve a vote on alternative answers and students could be asked to justify their responses. There should be an opportunity for students to change their ideas and to reflect on this.

Course resources
AT: Interactive *Concept cartoon: Too full or not too full?*

3: Talking about pressure
Securing
Prac **WS**
Demonstrate and discuss some experiments that can be explained with reference to air/gas pressures. After each experiment the students should be asked to write a description of what happens and an explanation using gas pressures.

Worksheets 7Ge-3 and 7Ge-4, which are designed to aid those working at *Securing*, outline the three experiments described below but other experiments can be substituted.

Course resources
AP: Worksheets 7Ge-3; 7Ge-4.

Experiment 1
Fill a glass completely with water, put a piece of card on top and invert the glass. The card should stay attached to the glass. Ask students to describe and explain what they have seen and the role of air pressure in keeping the card up. This will not work with beakers or any other containers that have a lip shaped for pouring. It is suggested that this is a teacher demonstration only, for reasons of mess rather than safety!

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⚠ Mop up any spills straight away.

Equipment
Drinking glass or other container with a flat rim, card.

Experiment 2
Place a small piece of burning paper in a conical flask and immediately place a peeled hardboiled egg in the mouth of the flask. The egg will 'bobble' a little as the air in the flask expands. Then when the air in the flask cools, the egg will seal the flask. As there is more pressure on the outside than the inside, the egg will be pushed into the flask by air pressure. Again ask students to describe and explain what they have seen in terms of air pressure.

⚠ Dispose of the egg immediately after use.

Equipment
Peeled hardboiled egg, conical flask or wide-necked drinks bottle.

Experiment 3
This practical originated as a party trick. Two plastic drink bottles are set up, with a balloon inside each of them, with the opening of the balloon stretched across the neck of the bottle. The bottles should look identical. However, a small hole, of about 1 mm, should be made in the bottom of one of bottles. Two students are then given a bottle each to try to blow up the balloon. One will blow up easily while the other will be impossible. Discuss possible reasons with the class before showing them the difference between the bottles. Ask students to describe and explain what they have seen in terms of air pressure.

⚠ The balloon should be discarded after use by each student.

Equipment
2 plastic drinks bottles, 2 balloons.

4: Water-filled barometer
Securing
Prac WS
Use a long glass tube sealed at one end, fill it with water and invert it into a trough of water. The water should stay in the tube. Explain to students why the water stays up. This is not actually a barometer – to be used as such the glass tube would have to be long enough to form a vacuum at the top (about 10 m long!). Worksheets 7Ge-6 and (homework) 7Ge-9 make use of this idea, and the drawings from those sheets may help explanations.

Course resources
AP: Worksheets 7Ge-6; 7Ge-9.

Equipment
Long glass tube, sealed at one end, trough of water.

5: Kinetic theory model
Securing
Prac WS
Kinetic theory models typically consist of a closed container containing small spheres, and a motor that can make the base of the container vibrate. If such a model is available, use it to reinforce explanations of the differences in particle arrangement and movement between the three states of matter.

Equipment
Kinetic theory model.

PLENARIES

Most plenaries can be used for formative assessment. Suggested assessment, feedback and action strands of formative assessment can all be modified. See the ASP for further information and ideas on formative assessment.

1: Thinking about pressure
Securing
WS
Assessment:
Plus, Minus, Interesting: Car tyres should not be filled with a gas. (Possible answers: **Plus** – you would not get punctures; **Minus** – more vibrations would be transmitted to the car or the ride would not be as smooth; **Interesting** – are all tyres filled with gas? Some types of tyre are solid and others are filled with liquid. Some are filled with air and others are filled with different gases, like nitrogen.)

Consider All Possibilities: A car tyre bursts. (Possible answers: there is a puncture; the pressure in the tyre was too high; the tyre got too hot.)

Odd One Out: pressure, density, volume. (Possible answers: pressure is the only one that depends on the movement of particles, it is the only one that involves a force; volume is the only one that does

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not necessarily involve particles; density is the only one that decreases with increasing temperature.)

Feedback: Students answer the thinking skills questions in groups, discussing the answers and giving feedback to one another.

Action: Ask students which of the exercises was best for revising air pressure. Ask a spokesperson from each of a number of groups to read out the best answer chosen by their group. Promote class discussion to point out if any ideas were wrong. Ask students how they can correct any mistakes.

The **AT** presentation *7Ge Thinking skills* can be used for this activity.

Course resources
AT: Presentation *7Ge Thinking skills.*

2: Particle theory presentation: Open-ended Assessment Task
Developing/Securing/Exceeding
FA **SA** **WS**
Ask groups of students to give a presentation on 'particle theory'. They could include models and/or electronic slides in their presentations, but the choice of what to do should be left to students to decide in groups. Skills Sheets RC 2 and RC 4 may help students. Once they have worked on their presentations they should give them to the class. Other groups use Worksheet 7Gb-6 to provide constructive feedback. You can assess this activity by using the Open-ended Assessment Task sheet or students can assess their own performance by using the Assess Yourself! sheet (see the ASP).

Course resources
AP: Skills Sheets RC 2; RC 4. Worksheet 7Gb-6.
ASP: 7G Assess Yourself!; 7G Open-ended Assessment Task.

3: Return to the collapsing cans and expanding marshmallows
Securing
Prac **WS**
Repeat the experiment of the collapsing can from Starter 1 and ask students to explain what is happening in terms of air pressure. They could also revisit their thoughts of Starter 1 and correct them.

You can extend this by connecting the vacuum pump to a clear, rigid bottle filled with marshmallows. The marshmallows will increase markedly in size. Make sure the vacuum pump tube is protected by a gauze mat (to stop any errant marshmallows getting into it).

⚠ Ensure that marshmallows are not eaten.

Equipment
Empty can or plastic drinks bottle, vacuum pump, bored cork/bung, glass tube, marshmallows, clear rigid bottle, gauze.

4: Concept maps revisited
Securing/Exceeding
FA
Assessment: Ask students to look again at the concept maps that they made in Starter 3 in Topic 7Ga. Ask them to amend and add to their maps.

Developing: Give students the Quick Check sheet for this topic and ask them to either fill in the concept map or to use the concept map on that sheet to help them add and amend their own maps.

Securing: Give students the words at the bottom of the Quick Check sheet to help them add to or amend their existing maps, or to develop new maps.

Feedback: Students work in groups to discuss and agree amendments to concept maps and Quick Check sheets.

Action: Students use the results of their discussions of the Quick Check sheets and their concept maps to highlight areas of difficulty. Teachers can concentrate on highlighted areas in revision.

Students should also be asked to name the topic they most enjoyed and the one they found hardest. In each case they should give a reason for their choice.

Course resources
ASP: 7Ge Quick Check.

5: Quick Quiz revisited
Developing/Securing/Exceeding
SA
Revisit the 7G Quick Quiz to test students' knowledge of the content of this unit. Students could fill in their answers on the 7G Quick Quiz Answer Sheet. Encourage students to identify areas for themselves that are still weak and decide how they are going to remedy this.

Course resources
ASP: 7G Quick Quiz; 7G Quick Quiz Answer Sheet.

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6: End of Unit Test

Developing/Securing/Exceeding

SA

Use one or both of the End of Unit Tests. A Mark Scheme is given in the ASP. Encourage students to identify areas that are still weak and to formulate plans to strengthen those areas. Summary Sheets are provided to help students with revision.

Course resources
ASP: 7G End of Unit Test (S); 7G End of Unit Test (H); 7G Mark Scheme; 7G Summary Sheets.

7: Progression Check

Developing/Securing/Exceeding

SA

Students should circle the stars next to each statement on the 7G Progression Check to record what they feel they know, and how certain they are of it. Encourage students to plan how to do further work on the things about which they remain unsure.

Course resources
ASP: 7G Progression Check.

HOMEWORK TASKS

1: Air and particles

Developing/Securing/Exceeding

Worksheet 7Ge-7 provides straightforward questions on gas pressure.

Course resources
AP: Worksheet 7Ge-7.

2: Revision puzzle

Securing

Worksheet 7Ge-8 is a puzzle that can be used to revise the material from the whole unit.

Course resources
AP: Worksheet 7Ge-8.

3: A weighty matter

Exceeding

Worksheet 7Ge-9 provides a more challenging comprehension on barometers.

Course resources
AP: Worksheet 7Ge-9.

ActiveLearn

Three ActiveLearn exercises are available for this topic: Gas pressure; Changing pressure; Pressure and vacuum.

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