Unit 7G Particle model of solids, liquids and gases

About the unit

In this unit pupils:
- learn how the particle model can be used to explain differences between solids, liquids and gases
- explore how experimental evidence relates to theories and models

In scientific enquiry pupils:
- use the particle model to explore the interplay between scientific theories and evidence
- evaluate whether evidence supports or refutes explanations of phenomena

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

This unit uses ideas developed in the key stage 2 programme of study. It builds on unit 4D 'Solids, liquids and how they can be separated', unit 5C 'Gases around us', unit 5D 'Changing state' and unit 6C 'More about dissolving' in the key stage 2 scheme of work.

This unit lays the foundation for subsequent work on particles.

Pupils will have many opportunities in later units to try to explain phenomena in terms of particles, *eg dissolving in unit 7H 'Solutions', changes of state in unit 8I 'Heating and cooling', digestion in unit 8A 'Food and digestion', crystal size related to rate of cooling in unit 8H 'The rock cycle', the behaviour of gases in unit 9L 'Pressure and moments'.*

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: describe and explain observations, using the particle model

some pupils will not have made so much progress and will: describe observations and try to offer explanations for them

some pupils will have progressed further and will: compare explanations of a phenomenon and evaluate whether evidence supports or refutes them

in terms of materials and their properties

most pupils will: classify materials as solid, liquid or gas; explain their classification of some 'difficult' materials; describe materials as being made of particles and describe the movement and arrangement of these, and begin to use the particle model to explain phenomena, *eg the mixing of liquids, the expansion of a metal bar*

some pupils will not have made so much progress and will: classify materials as solid, liquid or gas and recognise that materials are made of particles

some pupils will have progressed further and will: use the particle model to explain a range of phenomena

Prior learning

It is helpful if pupils:

- have experience of identifying solids, liquids and gases and describing the properties of each
- know that the same material can exist as a solid, liquid and gas
- have observed that melting solids and freezing liquids are the opposite of each other
- have observed situations in which evaporation and condensation take place

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:

- carry out a range of experiments which may be hazardous
- observe gases which are toxic and corrosive

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:

- words with a precise meaning in scientific contexts, *eg evidence, theory, model*
- words and phrases relating to the particle model, *eg particle, diffusion, gas pressure, vibration*
- words relating to scientific enquiry, *eg evidence, data*

Resources

Resources include:

- simulation software, three-dimensional models to illustrate particle arrangement and movement in solids, liquids and gases
- cards/information sheets for a 'murder mystery' or other problem-solving game

Out-of-school learning

Pupils could:

- look for stories (not necessarily in a scientific context) in newspapers, magazines and on television and radio where evidence is collected and considered, so that they appreciate the variety of situations in which evidence is important
- look for domestic and everyday contexts where gases, liquids and changes of state feature, in order to broaden their experience of the states of matter

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note

How can we explain evidence from experiments?

- to classify materials as solid, liquid or gas
- to use their existing knowledge and understanding to interpret and explain results
- to work together, listening to and evaluating the contributions of others
- that discussion can help clarify ideas

- Check that pupils are familiar with the terms 'solid', 'liquid' and 'gas' and have some understanding of what these mean. Present them with examples and ask them to allocate each example to the appropriate class.
- Introduce the idea that pupils will work in groups to carry out some quick experiments which will help them explain why solids, liquids and gases behave differently, *eg*
  - *comparing the masses of identically-sized blocks of two or three different materials such as wood, glass and metal*
  - *putting one small coloured crystal into a beaker of cold water and one into a beaker of hot water*
  - *trying to fit a metal bar into a gauge before and after strong heating*
  - *opening a perfume bottle at arm's length*
  - *heating one end of a metal rod that has paperclips attached by petroleum jelly*
  - *trying to depress the plungers of three sealed syringes, one containing a solid, one a liquid and one a gas*
  - *adding small weights, one at a time, to a thin wire suspended from a clamp until it snaps*
- Ask pupils to discuss with others what they observe and try to explain what has happened.
- If pupils cannot give any explanations to start with, it may be helpful to suggest that they try to imagine they can see what is happening through powerful microscopes.
- Ask groups of pupils to present observations and to describe and explain them, *eg through oral, flip-chart or overhead-projector (OHP) presentation.* Discuss different ideas with pupils and ask them to compare their own ideas with those of others.

- classify materials as solid, liquid or gas
- offer explanations (which may be incorrect) in which they try to link their existing knowledge to observations, *eg*
  - *the syringe which contains a solid won't squash because it's got no air in it*
  - *the metal rod expands because the particles get bigger*
- evaluate their own explanations and those given by others

- These activities should be carried out quickly. Their purpose is to encourage pupils to look for and give explanations for their observations. Most pupils will have incorrect ideas at this stage. They should be encouraged to evaluate them and compare them with those of others. They will be introduced to accepted explanations later in the unit.
- It may be helpful to have key phrases prepared for pupils to use.
- This work links to unit 7A(ii) 'Understanding materials (resistant materials)' in the design and technology scheme of work.

⚠ **Safety**

– use of the Bunsen burner is introduced in unit 7I 'Energy resources'. If pupils have not done this unit, they will need to be shown how to use a Bunsen burner

– handle crystals with forceps

– remind pupils that some things remain hot even if they do not look hot

– take care with sharp edges on glass or metal blocks

– use eye protection when adding weights to a thin wire and make sure feet are well out of the way of falling weights

– make sure pupils know what to do if something catches fire

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How are theories created?			
• to share and discuss ideas • that theories are based on experimental data • that sometimes new evidence results in changes to theories	• Introduce the idea that scientists collect data or evidence and that they try to think creatively to explain this evidence. Theories result from scientists relating their ideas to the evidence and refining their ideas. • Present pupils with a game or puzzle to play, *eg a murder mystery game*, where each group is given some evidence about an event, *eg a fictitious murder*, and is asked to establish what happened on the basis of the evidence. • Provide further evidence, which could be given part-way through, to encourage pupils to modify their original suggestion on the basis of the new evidence. Ask pupils to reflect on their ideas, to explain why they arrived at their first conclusion, and what caused them to change their ideas.	• evaluate the ideas of others and collectively create a solution to the game/puzzle which is consistent with the evidence • explain how their solution is consistent with the evidence and, if necessary, why they had to change their ideas	• The purpose of this activity is to help pupils see that data and theory relate. They will also see that it is often difficult to suggest theories that fit the data.
What are the differences between solids, liquids and gases?			
• that materials can be classified as solid, liquid or gas, but that some are difficult to classify • to evaluate their own theory in the light of evidence	• Give pupils a range of materials to classify as solid, liquid or gas. Include some materials that pupils find difficult to classify, *eg paper, sand, jelly, talc, toothpaste, tomato sauce, reusable adhesive, etc*. Tell pupils they should be prepared to justify their classification, making explicit the criteria they used. Ask them to list the properties of solids, liquids and gases and use this to develop a key for classifying materials. • Ask pupils to imagine they can see what the materials are made from by using an immensely powerful microscope and, in groups, to discuss and create their own theory or model of what the materials are made from. Invite pupils to communicate these to the class. At this stage, help pupils identify inconsistencies between theory and evidence, but do not give the correct particle theory.	• classify materials and justify their classification in terms of properties of solids, liquids and gases • explain why some materials are difficult to classify • generate descriptions of solids, liquids and gases consistent with the evidence and their scientific knowledge, *eg a solid is made of tiny grains all glued together* • design a key to classify materials as solid, liquid or gas	• This activity is familiar from key stage 2. The emphasis here is on pupils deciding the criteria for classification, thinking about whether these can be used in the cases they have and, if necessary, amending or refining their criteria. • One group may classify one substance as solid, while another may say it is liquid; this provides a good discussion point about the limitation of the solid/liquid/gas system for classifying and the need for clear criteria. • Many pupils will already have heard of particles; they may use terms for them, *eg atom*, *molecule,* perhaps incorrectly. • Some may confuse microbes, cells and particles and the differences will need to be made explicit (see unit 7A 'Cells').

3	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How can the particle model explain the differences between solids, liquids and gases?				
	• that models can be used to explain phenomena which cannot be observed • that sometimes new evidence requires changes to models • that solids, liquids and gases are made up of tiny particles • that the differences between solids, liquids and gases can be explained in terms of the proximity and motion of their particles	• Using a variety of media, *eg simulation software, three-dimensional models, diagrams, texts, modelling using pupils*, make explicit to pupils the accepted theory about particles in terms of their proximity and motion. • Through discussion and questioning, establish the similarities and differences between their theories and the accepted one and show how the accepted one explains the evidence.	• describe in writing and drawing the arrangement, proximity and motion of particles in solids, liquids and gases • describe how particle theory can explain some phenomena, *eg diffusion of a gas, mixing of liquids, expansion of a metal bar*	• At this stage it is important to establish the key ideas of particle theory with pupils. It may be helpful to point out that these ideas were established gradually over a long period of time, and that some scientists once had ideas similar to some of the pupils' ideas and had to modify them.
How can the particle model explain other phenomena?				
	• to apply a model to new phenomena to explain behaviour • how discussion can help clarify ideas	• Invite pupils to carry out additional quick experiments in groups, *eg* – *placing coloured crystals on agar gel and observing the diffusion of colour* – *placing distinct layers of water and ink in plastic syringes and observing the mixing of colour over a short period of time* – *observing dust particles in a beam of light* • Ask them to try to explain their observations using knowledge and understanding about particles, discussing their ideas with each other. Explain that they must check that the explanations they will give to the class later include use of the particle theory.	• explain observations in terms of particles • evaluate their own explanations and those of others	• This work could be available over a period of time to allow pupils the opportunity to assimilate and apply particle theory. The specific phenomena used are not important provided they allow pupils to practise applying their knowledge. • In unit 7H 'Solutions', pupils consider what happens when solids dissolve in liquids. This will provide them with further opportunities to apply and consolidate their knowledge. ⚠ **Safety** – use forceps for handling crystals and choose those that can be handled safely

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
• that gas particles are moving around all the time • that gas pressure is caused by particles hitting the walls of the container	• Give pupils access to all the experiments they had at the start of the unit and ask groups to present explanations using particle models, *eg orally or using flip charts, OHPs.* • Demonstrate that gases mix by diffusion, *eg by mixing bromine and air, or nitrogen dioxide and air, or allowing gas jars of hydrogen and air to mix.* Use a range of methods, *eg video clips, simulation software, pupils modelling*, to illustrate the movement of gas particles and explain diffusion. • Discuss with pupils the idea of air particles all around before demonstrating the collapsing can experiment. Ask pupils, in groups, to explain why the can collapses; link their ideas back to pressure of gas inside and outside the can.	• explain their observations using the particle theory • identify where there are contradictions in their ideas, when these are pointed out • describe gas particles as moving all the time and pushing against surfaces • explain that the can collapses because there are fewer air particles on the inside pushing out than on the outside pushing in	• Pumping air out of a can works well and helps pupils to focus on air inside and outside the container. Many pupils explain the collapse of the can in terms of air being sucked out rather than in terms of movement of molecules. • Pupils will have opportunities to revisit diffusion in unit 8F 'Compounds and mixtures' and unit 9L 'Pressure and moments'. ⚠ **Safety** – bromine and nitrogen dioxide are toxic and corrosive. Employer's risk assessments must be followed
Reviewing work			
• how to make notes and summaries to clarify ideas • to summarise the particle theory in writing and drawing	• Ask pupils to make annotated drawings to describe the arrangement and movement of particles in solids, liquids and gases. Ask them to choose two of the experiments they have carried out, or have seen, and describe what they did, what they observed and to explain their observations in terms of the particle theory.	• draw and describe particles in solids, liquids and gases in terms of the movement and proximity of their particles • describe observations they have made and explain them, *eg a metal block is heavier than a wooden block because the particles are heavier or because the particles are closer together*	• Many pupils will need more time and practice to grasp these ideas. They are revisited in many units – see 'Where the unit fits in' at the beginning of this unit.

