Chemical elements

4.1 The properties of matter can be described

Teacher notes (pages 62–63)

Introducing the chapter

Students should have prior knowledge of a large amount of this topic from Science in Year 7, including the particle model of matter, the physical properties of matter and the separation of mixtures. This chapter will build on previous knowledge and skills, extending the topic to a greater depth. Matter is the name given to all substances. To be called matter the substance must have mass and volume.

Teaching tips: Student understanding

Questioning of students or a pre-test would be useful in revealing students’ understanding and any misconceptions. The hands-on activities provided in this chapter are recommended in order to engage students with this topic.

Teaching tips: Ability levels

The concepts presented in this chapter can be overwhelming for those students with lower abilities, yet they can often cope quite well with the hands-on activities. Most students think they have to memorise the periodic table, but this idea is out of date. The periodic table is usually provided in senior chemistry exams and so students should have access to the periodic table in the assessment tasks at this level. Teaching students how to use the table and where to look for various elements is essential.

Differentiation

For less able students:

Less able students could draw up a four-column table with the headings solids, liquids, gases and plasma. Students brainstorm as many of each type as they can think of for each heading. Keep in mind that students will encounter much more difficulty with plasma in this task.

For more able students:

More able students may wish to use an ‘entry ticket’ task where they brainstorm as much as they can about what they already know about the states of matter. Some may already have a good understanding of the particle model and may be able to illustrate each of the states of matter.

Additional activity: Identifying states of matter

Students draw a scene in which many examples of the states of matter can be identified. An example could be the school yard, with a drinking fountain (liquid), a flag moving in the wind (gas) and a student kicking a ball (solid). Students complete their comprehensive illustrations on an A3 sheet of paper and then swap with another student to see if they can identify all the examples of solids, liquids and gases. You can discuss any examples that students are unsure about (e.g. a melting ice cream).

Additional activity: Solids, liquids and gases

Water is an excellent example to differentiate between solids, liquids and gases, as students know the different states of water:

• solid: ice/iceberg

• liquid: water/ocean

• gas: steam/clouds

Ask students to identify more examples of the states of matter (not necessarily based on water).

Additional activity: Minute paper

At the end of this section/topic, give students a small piece of paper (an eighth of an A4 page at the most) and ask them to summarise what they have learnt on this paper in one minute. This minute paper can allow you to gauge how well students understood the new concepts introduced and focus on aspects that they may benefit from revisiting at the start of the next lesson. Minute papers can have the students’ names on the back or handed in anonymously.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**Chem4Kids: Plasma basics**  
The webpage contains a video explaining the nature and applications of plasma.

4.2 Scientists’ understanding of matter has developed over thousands of years

Teacher notes (pages 64–65)

Introducing the topic

This section explores the history of science and some of the most important scientists who study chemistry. Science involves developing hypotheses, testing them with reproducible experiments and modifying ideas. When an idea is supported by all the current evidence, it then becomes a theory. The particle theory of matter is a great example of this – it has been tested and refined by scientists over more than 2000 years.

Teaching tips: Electrons through the ages

Electrons are a good example of something that we have learnt more and more about. The Ancient Greeks thought they might exist, and then a series of breakthroughs in the twentieth century saw them shift from theory to fact. Students could also use this as a research task.

Teaching tips: Modern science

The invention of new technologies means that more and more is being discovered about science all the time. One example of this is the microscope. Ask students what the invention of the microscope meant for science. Then ask them to think about other technology that has led to new insights and breakthroughs in science. There are many!

Additional activity: Archimedes in his bath

The story of Archimedes’ bath is famous. While taking a bath, Archimedes noticed that the water level rose when he got in. This is how many people think he made his discovery about density. Students often learn better by seeing things done rather than just learning about them. Fill a garbage bin with water and ask students to submerge large objects in it. They can then use the amount of displaced water and the weight of the object (mass) to calculate the density. Ideally, students should test differently shaped objects of the same mass.

Additional activity: Developing the atom

John Dalton’s work was essential to our understanding of the atom, but he certainly wasn’t alone. Ernest Rutherford, JJ Thomson, James Chadwick, Niels Bohr and Erwin Schrodinger all developed Dalton’s model to create the view of the atom that we have today. Students could research one of the scientists above, and produce a poster about his life and contributions to the atomic model.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**BBC Bitesize: The particle model**  
This website contains an interactive animation about how the particles in solids, liquids and gases behave.

4.3 The particle model explains matter

Teacher notes (pages 66–67)

Introducing the topic

The particle model states that particles are always in motion. It also states that particles move faster when heated and more slowly when cooled. This also explains why, when things are heated, they expand and when they are cooled they contract. The effects of this movement can be seen clearly with gases, where contained particles create a force measured as gas pressure and released gases diffuse into the air. The scent of perfume is a good example of diffusion.

Teaching tips: Common misconceptions

• ‘Atoms are hard, like billiard balls.’ (In fact, atoms are the smallest particle that cannot be broken down any further.)

• ‘Atoms are like cells with a membrane and nucleus.’ (In fact, atoms are the smallest particle and cannot contain organelles. In addition, atoms are non-living, whereas cells are living.)

Differentiation

For less able students:

Less able students could draw an illustration of three types of matter – solid, liquid and gas.

For more able students:

More able students could design an experiment that shows the transition between three states of matter – solid, liquid and gas. The most obvious example of this is the transition from ice to water to water vapour.

Additional activity: The particle model of matter

You may like to use role-plays to revise the particle model of matter, using a group of students (or the whole class) to act like particles in a solid, liquid and gas. This is a fun practical activity that can consolidate students’ knowledge about solids, liquids and gases and the movement of particles. To add to this role-play, ask students to include a section where they are cooled or heated to show a decrease and increase in movement.

Additional activity: Modelling atomic behaviour

Students will commonly use atomic model balls, plasticine or lollies to represent atoms. They will use toothpicks to join them into molecules. These are all legitimate items to use.

Additional activity: Mind map

A mind map can be an effective and visual way for students with low literacy skills to engage with the concepts in this section. A mind map featuring the key words with key linking terms could be completed by students, ensuring that the major concepts have been understood. Key words could include element, atom, compound, solids, liquids, gases and particles.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**BBC Bitesize: Behaviour of matter**  
This website contains an interactive presentation about the behaviours of solids, liquids and gases under different conditions.

4.4 The particle model can explain the properties of matter

Teacher notes (pages 68–69)

Introducing the topic

This topic discusses the physical properties of matter including strength, hardness, viscosity, compressibility and density.

Teaching tips: Properties

Each element or substance exhibits different properties. Properties help us describe and identify a substance and determine what to use and when. Physical properties can be observed or measured without changing the composition of matter. These physical properties make a good starting point for learning about this topic. Students could be encouraged to investigate the physical properties of different elements or substances. They could choose one or two substances or elements and find the properties (boiling point, melting point, strength, hardness etc.) for the substances or elements they choose.

Additional activity: Investigating particle pressure

Air pressure is maintained in a number of places, most commonly in commercial aircraft cabins. This is to maintain a safe and comfortable environment in the low atmospheric pressure outside the aircraft. The human body can only withstand certain atmospheric pressures and, as such, cabin pressurisation is needed. Physiological problems, such as altitude sickness, decompression sickness, hypoxia and barotrauma, may occur if pressurisation is not correct. Students should be encouraged to talk about their experiences in a pressurised cabin. Such things as blocked ears and feeling dizzy and tired are common experiences when flying, due to pressurisation.

Additional activity: Ice-cube necklace

A demonstration of the changing properties of matter could help students grasp the states of liquid, solid and gas. Water is particularly useful for this. Pure water freezes at 0°C and by adding salt the freezing temperature of water is reduced. Salt and other solutes reduce the freezing point because they disrupt the crystal structure of ice and reduce the concentration of pure water. At 0°C, the molecules in pure water form very strong bonds with each other, locking them into position to form a solid. If foreign molecules, such as salt molecules, squeeze between the water molecules, the strong bonds cannot form. Any reduction in the concentration of pure water reduces the freezing point. So the higher the salt concentration, the lower the freezing point. When salt is sprinkled onto an ice cube, the local salt concentration increases and the freezing point lowers. The melting water flows off the cube and flushes some of the salt away, reducing the local concentration on top of the ice cube. The lower salt concentration raises the freezing point again so the water refreezes, trapping the string.

Additional activity: Student-designed experiments

Students can design experiments to investigate several aspects of state change. Some possible ideas for these experiments:

• How does change of state affect volume?

• Does pure or salt water freeze faster?

• Does hot or cold water freeze faster?

• Will water evaporate faster than octane?

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**Changing water**  
This animation of the changing states of water shows students the many ways in which water can change its state.

4.5 Increased kinetic energy in matter causes it to expand

Teacher notes (pages 70–71)

Introducing the topic

In this section, students consider how energy can change in particles. When heated, particles move more rapidly; when cooled, they slow down. In a cold drink, the particles have less energy than in a hot drink. In a hot drink, the particles have so much energy that often vapour can be seen rising from a mug – this is because the particles have broken their bonds and become a gas.

Teaching tips: Use of video

This topic can often be best learnt using video and animation. The behaviour of particles is best seen and understood through a visual medium.

Differentiation

For less able students:

Less able students could use a cloze activity to access this text-heavy topic.

For more able students:

More able students could be challenged to design an experiment that shows that hot air expands and cold air contracts. Students could then carry out the experiment. This could be also used as an assessment.

Additional activity: Making a hot-air balloon

Simple, small hot-air balloons can be created and launched at school. A number of templates for this experiment, including important safety instructions, can be found online.

Additional activity: Diffusion of a gas

Use a perfume or air-freshener bottle to demonstrate the diffusion of a gas. You should spray the perfume at the front of the class, and ask the students to raise their hands when they can smell it. This will allow students to visualise the diffusion of the gas throughout the room.

Additional activity: Air pressure

Even though we can’t feel it, every person on Earth is constantly being squeezed by the air pressure around us. However, it is balanced by the pressure from inside our bodies, and so we aren’t crushed. We can investigate what would happen when we remove the pressure from inside an object by using a soft-drink can. Add a teaspoon of water to an empty soft-drink can, and heat the can over a Bunsen burner. This will convert the water to steam, and reduce the amount of air in the can. Once the water has boiled off, the can should be placed open-side down into a tub of water. This will rapidly cool the steam, resulting in a significant drop in pressure. Consequently, the air pressure from the atmosphere will be stronger than the pressure inside the can, and the can will be crushed.

Additional activity: Models

Students can use toothpicks and plasticine (or similar) to create models of the lattice structure found in solids. They can also model the addition of heat and break them apart to create a liquid model. The particles in liquids can ‘flow’ over each other, which could also be modelled. An accompanying verbal explanation may add value to the task.

Additional activity: Sublimation and deposition

Sublimation and deposition are quite rare changes of state. Students could research which substances and under what circumstances these two processes will occur.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**BBC Bitesize: Particle model**   
This website contains revision on how the particles in solids, liquids and gases behave.

4.6 Atoms and elements make up matter

Teacher notes (pages 72–73)

Introducing the topic

Elements can be arranged into groups depending on their properties. The periodic table is an ordered list of all the elements. Learning how to read and understand the periodic table is a key area of understanding in science.

Teaching tips: Atomic model kits

These are a good way to demonstrate that elements are the building blocks of chemical substances; each element is represented by a different coloured ball. An illustrated poster of the periodic table is useful, too. Interactive periodic tables can be found online. These highlight the different groups of elements, provide specific information about each element and show periods and groups. Pocket-sized periodic tables can also be sourced online and printed out and distributed to students so they always have access to one. The periodic table can be daunting to many students and it does contain a lot of information. It is important that students know what kind of information the table includes. You can discuss the atomic number (at the top), which indicates how many electrons/protons the atom has, and the atomic weight (at the bottom), which is roughly equal to the number of protons and neutrons. The protons and neutrons are found in the nucleus of the atom, giving it nearly all its mass. You can also discuss which elements are naturally occurring and which are artificial.

Teaching tips: Common misconceptions

It might be useful to address common misconceptions at the start of the topic. These are some examples:

• ‘Because water is pure it must be an element.’ (In fact, water is a compound because it contains two elements: hydrogen and oxygen.)

• ‘The periodic table is complex.’ (In fact, it isn’t; it has order and structure.) Many people believe the periodic table is too difficult to memorise. No student should be expected to memorise the periodic table. Rather, students should have access to a copy they can use at any time.

Differentiation

For less able students:

Less able students would benefit from colouring in their own black and white copy of the periodic table, showing each group as a different colour, and the use of video when describing the properties of each group of elements.

For more able students:

More able students could design and create a memory game that teaches students the first 20 elements of the periodic table. Some examples of this go from the simple, such as flash cards and bingo, to the more complex, such as Periodic Table Battleship.

Additional activity: Adopt an element

Students are required to research an element, create an advertisement and complete an element fact sheet. Many project sheets for ‘adopt an element’ exist online.

Additional activity: Remembering the periodic table

There are some good games that can be played to assist students with remembering elements from the periodic table. An example of this is Periodic Table Bingo. Periodic Table Bingo gives students a grid of various elements’ symbols (e.g. C, K, Na), you then read the name of an element and students must remember the symbol in order to be able to cross it off. There are many free templates for Periodic Table Bingo available online.

Additional activity: The periodic table

Students could research different forms of the periodic table to show that it doesn’t just exist in the standard form.

Additional activity: Student-designed experiments

Students can design experiments that test viscosity, conductivity, refractive index, heat capacity or compressibility. An experiment testing compressibility may be easier to design than one on refractive index. Students must write a full experiment report including a testable hypothesis, materials and methods. The best student-designed experiments could be tested by the class.

Additional activity: Conductivity

If time permits, allow students some time to test conductivity using simple circuits. Although students may not have used simple circuits before, they are very easy and safe to use. Students can set up a simple circuit and test the conductivity of various items. They can then see firsthand that some substances are conductors and some are insulators. Suggested items for testing include a strip of aluminium, a nail, a piece of rubber, a piece of fabric, a paper clip and a piece of wood or paddle pop stick.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**Dynamic periodic table**  
This website contains an interactive version of the periodic table of the elements.

4.7 Atoms bond together to make molecules and compounds

Teacher notes (pages 74–75)

Introducing the topic

Elements can combine to form compounds and molecules. There are thousands of compounds around us. Compounds have different properties from those of the elements that form them.

Teaching tips: Compounds

Compounds occur when two or more types of element are combined together. An example of this is water – H2O. Another example is table salt, which is made up of sodium and chlorine (NaCl).

Teaching tips: Mixtures

A good mixture that can be readily examined in the school laboratory is soil. Many of the concepts presented in this section can be explored with the soil sample, for example, why is it a mixture? Is it homogeneous or heterogeneous? A sand sample can be examined, too, if your school is near the beach.

Additional activity: Edible molecules

Students create models of molecules using lollies. By the end of this activity, students should understand that molecules can be either elements (made from the same type of atoms) or compounds (made of two or more different types of atoms).

**Materials**

• 4 miniature marshmallows (oxygen)

• 7 red gum drops (hydrogen)

• 7 green gum drops (chlorine)

• 2 yellow gum drops (sulfur)

• 25 toothpicks (covalent bonds)

**Method**

**1** Construct models of the following molecules: H2, HCl, H2O (Hint: Attach the hydrogen at right angles to the oxygen.)

**2** Now construct models of these molecules: Cl2, H2S, Cl2O and Cl2S.

**3** Classify the molecules as a gas, liquid or solid at room temperature.

**4** Draw diagrams of each of the model molecules you have constructed.

**5** Compare your models with the actual structure of the molecule.

To extend students, discuss chemical formulas. Students should understand that the chemical formula for a molecule or compound shows the number of each type of atom or element in the molecule. The numbers, written as subscripts, are determined by the bonding between the atoms. In the models constructed, the toothpicks represent the bonds between the atoms.

Additional activity: Writing simple chemical equations

Scientists use symbols to write out chemical equations in place of full words. H2O is an example of this. Instead of writing out 2 hydrogen and 1 oxygen atoms, H2O is a faster way of presenting the information.

Give students some small common chemical equations to write out:

Hydrogen and oxygen gases combine to form water.

Magnesium burns in oxygen to form a white powder – magnesium oxide (this can also be done as a practical/experiment in class).

Additional activity: Polymers

To augment this section, you could show students a range of polymer items and ask them to group them into like items. The recycling codes could also be explained and used as a basis for this.

Going further

A useful weblink is available on your obook/assess. To access it, click the weblink tile on the Dashboard for this unit.

**BBC Bitesize: Compounds and mixtures**  
This website contains a presentation about compounds, elements and mixtures, followed by a short quiz.