Unit 8E Atoms and elements

About the unit

In this unit pupils:
- learn that the huge range of materials is made from a relatively small number of elements
- learn that each element is composed of one sort of atom only
- explore the characteristics of some elements
- use the particle model to describe what happens when elements combine

In scientific enquiry pupils:
- model differences between particles in elements and non-elements
- organise and sequence information from secondary sources
- choose an approach to find out whether a substance is an element or not

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

This unit relates closely to unit 7G 'Particle model of solids, liquids and gases' and unit 7H 'Solutions', in which the particle model is introduced and developed. However, if teachers wish to introduce the idea of particles through elements and compounds, it could be taught before these units.

The unit provides a foundation for unit 8F 'Compounds and mixtures', unit 9E 'Reactions of metals and metal compounds' and unit 9F 'Patterns of reactivity'.

The historical impact of ideas about atoms is covered in unit 21 'Scientific discoveries' in the history scheme of work.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: select information about elements and their properties from a range of secondary sources; describe how to deal with hazards when preparing oxides; identify an approach to finding out whether a material is an element or not and explain how their results provide appropriate evidence

some pupils will not have made so much progress and will: find information from selected secondary sources about elements and their properties; describe some hazards in preparing oxides and describe the results of their investigations

some pupils will have progressed further and will: select secondary sources to provide the information needed about elements and their properties; identify limitations of evidence obtained about whether a substance is an element or not, where appropriate, suggesting alternative explanations

in terms of materials and their properties

most pupils will: recognise that there is a small number of elements and name some of these; explain that compounds are made when atoms of different elements join together; begin to use symbols for elements and to represent reactions in word equations

some pupils will not have made so much progress and will: name some elements and represent these by symbols; distinguish between symbols for elements and formulae for compounds; name a wide variety of materials

some pupils will have progressed further and will: identify elements whose properties do not fit the general pattern of metals and non-metals; begin to represent compounds by formulae

Prior learning

It is helpful if pupils:
- understand the differences between solids, liquids and gases
- have seen and described changes of state
- know how models can be used to explain phenomena

Health and safety

Risk assessments are required for any hazardous activity. In this unit pupils:
- observe reactions of a variety of elements
- plan and carry out an investigation of copper carbonate

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 classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:
- scientific words, *eg element, compound, atom, molecule, symbol, formula*
- names of elements and compounds, *eg oxygen, carbon dioxide, sodium, chlorine, sodium chloride*
- words and phrases with different meanings in scientific and everyday contexts, *eg element, equation, state*
- words relating to scientific enquiry, *eg data search, predicting products of reactions*

Through the activities pupils could:
- discuss and question what they are learning
- undertake independent research using knowledge of how texts and databases are organised and of appropriate reading strategies

Resources

Resources include:
- model-building-brick system
- a collection of materials, including biological materials, *eg leather, bone, wood*
- access to information sources, *eg CD-ROM, internet, data books*, which can be searched
- paper/card cubes or thick paper from which cubes can be made
- large periodic table which can be placed on a table or floor
- individual copies of the periodic table for pupils
- copies of pupils' periodic tables in other languages
- samples or photographs of a wide variety of elements
- models, or photographs of models, of a range of molecules, including very large structures, *eg DNA and enzymes*
- software simulations of chemical reactions

Out-of-school learning

Pupils could:
- ask grandparents and other older people about materials that were used for clothing and utensils before plastics and synthetic fibres became so widely available

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How many different materials are there?				
	• that there is a huge variety of materials • that there is a small number of elements from which all other materials are made	• Show pupils a collection of elements and materials of different kinds, including some elements, some living things and some rock samples, to illustrate the huge variety of materials that exists. Ask pupils to suggest names of other materials. List a number of these, separating out any elements mentioned, and ask pupils to suggest why these have been listed separately. Introduce the term 'element'. Ask pupils to suggest names of other elements and explain that in this unit they will be finding out why elements are important and how they are different from other materials. Establish with pupils that there are approximately 100 elements and that these are the building blocks of all materials. Point out that we can't possibly count the number of materials that can be made from them.	• name a wide variety of materials • describe elements as the materials from which everything else is made	• It is helpful to include gases, *eg chlorine,* in the collection so pupils recognise these as materials. • At key stages 1 and 2 pupils will have begun to distinguish between an object and the material from which it is made. Some pupils will continue to need help with this. • Some pupils are likely to be familiar with the word 'element'. It may be helpful to point out that many, but not all, elements are metals and to classify materials simply as 'metals' and 'other elements' or 'metals' and 'non-metals' at this stage. ⚠ **Safety** – elements that are hazardous, *eg chlorine, bromine, sodium*, can be used as sealed samples if the teacher keeps careful control

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What are elements made from?			
• to distinguish between elements and other materials • that each element is made up of one sort of particle and these are called atoms • that models can be used to illustrate phenomena that cannot be observed	• Use a model-building-brick system to show that there is a limited number of types of brick out of which everything can be made. Explain that we believe that everything in the universe is made out of a limited number of building blocks, but the diversity of things is determined by the ways in which these blocks are assembled. • Model elements and other materials by showing pupils structures or materials made of only one kind of brick and others made of several. Ask them to decide and explain which are like elements and which are not. • Take some objects made of only one type of brick and pull them apart until they can't be pulled apart any more. Explain to pupils that if you take a piece of element, *eg aluminium or carbon,* and pull its particles apart like the bricks, you would end up with a pile of the smallest particles of the element that can exist. Scientists call this particle an atom. • Check pupils' understanding that elements are made of one kind of particle only by asking them to draw pieces of a few named elements, then draw the individual atoms after the element pieces have been pulled apart as much as possible. Ask pupils to label the atoms and the elements and write about what the two words mean in science. Extend to models of non-elements. • Introduce the idea of a chemical symbol representing an element, *eg by displaying some samples of elements with the symbols attached*.	• show by their drawings that they have some understanding of the relationship between elements and atoms and between elements and non-elements • recognise the symbols for some elements	• Throughout this unit it may be helpful to emphasise that classification of materials is a way of making sense of the wide variety that exists. • It is important that pupils realise it is a material, and not an object, that is being modelled. Teachers could use other models, *eg atom/molecule kits, models of crystal structure, ICT simulations*, as alternatives or additions. • Many pupils will not arrive at the correct understanding about elements and atoms immediately. It may be helpful to make it explicit to pupils that these ideas become clear as they use and become more familiar with them. • Some teachers may wish to introduce the idea that the symbol represents one atom of the element, but others will not feel it necessary at this stage. • Teachers may wish to explore some of the limitations of the model with some pupils, *eg you can build many 'materials' from one size of red brick, but one type of atom forms one element*.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What are elements like?			
• to undertake independent research using knowledge of how texts and databases are organised and of appropriate reading strategies • that elements vary in their appearance and state	• Make clear to pupils that they are each going to find out about some elements using secondary sources of information, *eg CD-ROM, internet, data books,* and that the information they collect will be used by the whole class to get a picture of what many of the 100 or so elements are like. • Give groups of pupils the names of around five elements and ask them to search for the following data on each element: – its symbol – its state at 20°C – whether it is described as a metal or a non-metal – whether it is described as magnetic or not – its appearance – any other information they might think important • Ask pupils to transfer these six pieces of information onto the six sides of a cube, colour-coded for: symbol; metal/non-metal; solid/liquid/gas; magnetic/non-magnetic; appearance; other information. Where possible, show pupils samples or photographs of the elements so that they can compare them with their research. Show pupils a periodic table and ask them to arrange their cubes according to the arrangement of the periodic table, with each face uppermost in turn. Ask pupils to answer a series of questions, *eg Where are the metals? How many elements are gases/liquids?* Explain that the periodic table shows all the elements and that similar elements are grouped together.	• locate and record the required information, *eg complete the six faces of the cube* • describe some differences between elements • make some generalisations about elements, *eg there are more metals than non-metals; most metals are non-magnetic*	• Pupils will need to be shown how to search the internet for the information they need, and how to select from all the information the key points you want them to focus on. They should be encouraged not to record anything they do not understand. • Many websites contain information about elements, *eg* – *www.shu.ac.uk/schools/sci/chem* – *www.knowledgebydesign.com/tlmc/tlmc.html* – *www.chemsoc.org/viselements/pages/data/* – *www.sciquest.com/* • At this stage it is not necessary to go into detail about how elements are arranged in the periodic table, although some teachers may wish to do so with some pupils. • Extension: pupils could be allocated a particular element and asked to find out interesting information about it and to contribute to a class display about elements.
Checking progress			
• to distinguish between elements and other materials • that each element is made up of atoms of one kind	• Provide groups of pupils with a set of statements, *eg* – *neon has only one sort of atom* – *there are more non-elements than elements* – *an apple is an element* – *very few elements are liquids at room temperature* – *all gases are elements* – *water is an element: it is made of hydrogen and oxygen atoms* and ask them to agree whether they are true of false. • Discuss pupils' answers with them and agree a list of key points about atoms and elements. Provide pupils with their own copy of the periodic table on which they can mark particular things, *eg metals/non-metals*.	• classify materials as elements and non-elements • explain their classification • identify that elements are made from atoms of one kind • make some generalisations about elements	• Periodic tables used in other countries can be used to show pupils that the symbols for the elements are the same. These may be found on the internet.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How do we get all the other materials?			
• that new materials are formed when atoms join together in different ways • that compounds are formed when atoms combine • that atoms can combine to form molecules	• Remind pupils of all the materials they mentioned in the first activity and ask them to suggest how these might be made from the limited number of atoms of different kinds. Remind them of the earlier activity using bricks as models and of some of the 'materials' that were made from bricks of different kinds. • Establish the idea that when these materials are made the atoms combine or join. Introduce the terms 'molecule' and 'compound', show models or photographs of models, of simple and more complicated molecules, to illustrate the point. If possible also provide samples of the compounds and their formulae.	• explain the existence of compounds in terms of atoms joining together • describe compounds, *eg water is made of hydrogen and oxygen joined together* • describe some simple molecules, *eg carbon dioxide is made of one carbon atom joined to two oxygen atoms*	• It may be helpful if pupils make their own models of some simple molecules and relate these to their chemical formulae. • Some teachers may want to include models of giant ionic/covalent structures. It is not necessary at this stage to explain the difference, although it is important to avoid talking about a molecule of sodium chloride, for example. • Extension: pupils could find out about 'new' compounds (there are about 5000 registered each day).
How can we represent the changes when new materials are made?			
• that atoms of elements combine to form molecules of compounds • that in chemical changes new substances are formed • to represent and explain chemical reactions by word equations, models or diagrams	• Show pupils some reactions between elements, *eg* *– hydrogen and oxygen* *– sodium and chlorine* *– carbon and oxygen* *– copper and sulfur* and ask them to record their observations in terms of the appearance of the reactants and the products and to represent the reactions by word equations, simulation software, models or diagrams, making clear that when the compound is formed the atoms join. Help pupils to represent the compounds formed by formulae and models. Ask pupils to explain individual reactions in these terms and to question others about their representations. • Extend by showing that water can be split into hydrogen and oxygen by electrolysis.	• describe what happens in some chemical reactions and name the product • explain compound formation in terms of atoms joining, *eg using equations, diagrams, models* • show understanding of compound formation in asking questions about others' representations of chemical reactions	• Pupils will have seen the burning of some elements in oxygen in unit 7F 'Simple chemical reactions', where they first encountered word equations. ⚠ **Safety** – eye protection and safety screens should be used. Ensure pupils are at a safe distance. Sodium is corrosive and highly flammable, chlorine is toxic and irritant. Some of these reactions are violent. With copper and sulfur there is a risk of producing toxic and irritant sulfur dioxide – hydrogen and oxygen: don't explode more than 300 cm^3 hydrogen indoors. Hearing protectors are needed if a large volume is exploded outside – sodium and chlorine: place dry sand (50p size) on a heatproof mat. Place a piece of cleaned-up sodium on a crucible lid, ignite, quickly invert a gas jar of chlorine over it – copper and sulfur: use about 3g copper and 1.5g powdered roll sulfur in a borosilicate boiling tube. Insert a plug of mineral wool in the top. Heat until the reaction starts

5	Learning objectives	Possible teaching activities	Learning outcomes	Points to note
	Pupils should learn:		Pupils:	
	• to predict what might be formed from a chemical reaction between elements • to heat metals in air safely	• Invite pupils to investigate one or more simple reactions first hand, *eg what happens when magnesium ribbon is heated strongly in air.* Encourage pupils to predict what the product might be on the basis of their prior work. Suggest that they identify and evaluate the product by comparing its appearance and behaviour with that of a known sample of magnesium oxide. Similar experiments could be carried out with zinc and copper to form their oxides. • Ask pupils to represent the reactions as in the previous activity and to predict what might be formed in other reactions.	• predict the product of some simple reactions, *eg zinc oxide from zinc and oxygen, iron sulfide from iron and sulfur* • interpret the names and/or formulae of binary compounds in terms of the elements of which they are composed • make a sample of an oxide safely	• Teachers may need to explain that it is not true that all chemical reactions involve elements as reactants and compounds as products. Pupils will consider reactions between compounds in later units. • Pupils will need time to practise using the chemical names of compounds, *eg making the change from oxygen to oxide*. • It is helpful for pupils to become familiar with formulae for common compounds and to relate these to models showing the numbers of atoms. Teachers will be able to judge how far to take explanations of differences in formulae with different pupils. • Extension: list, for some pupils the formulae of the products of the reactions seen and introduce the idea of 'combining power', using a simple model, *eg card cut-outs of elements; ball-and-spoke models*. Ask pupils to use the models to predict the formulae of other metallic oxides, chlorides and sulfides. It is helpful to be explicit that the models are not representations of real atoms. ⚠ **Safety** – when magnesium is heated, eye protection should be used and the burning metal should not be looked at directly

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Reviewing work			
• to distinguish between elements and non-elements • to identify the scientific knowledge relevant to a particular question • to make sure they are working safely • to explain how their work provides evidence about a question • to discuss and question what they are learning and how it is relevant when using different variables	• Give pupils sets of statements, *eg* *– made of only one sort of atom* *– symbol C* *– formula KF* *– made of different atoms joined together* *– made of atoms* *– gives off carbon dioxide when it is heated* *– a solution of salt in water* and ask them to decide whether or not an element is described or whether it is not possible to tell. • Extend for some pupils with more challenging statements, *eg* *– formula CO* *– symbol Co* *– formula O_2* *– breaks into two new materials when it is heated* • Explain that they are going to test their understanding in a practical activity and provide them with a sample of an 'unknown' material (copper carbonate) and challenge them to find evidence (practical or from data) of whether it is an element. Where necessary, prompt pupils by referring back to the first part of the activity. Ensure that what pupils propose is safe and, where necessary, help them to carry out their plan. Ask pupils to record what they did, their results and to explain what their results show. Discuss pupils' results with them and invite them to ask each other questions about what they did and what it showed. Bring together evidence from all investigations. • Help pupils to summarise the reactions of copper carbonate in a word equation, making clear which reactants and products are elements and which are compounds. Emphasise that the changes are chemical reactions in which new materials were made.	• identify statements describing elements and non-elements, explaining their decisions • identify methods that will provide appropriate evidence, *eg comparison of appearance with appearance of elements; change in mass on heating* • carry out their work safely • explain how their results provided evidence, *eg it changed colour and lost mass; if an element joins with something else it will gain mass*	• Pupils may suggest a variety of things to do, *eg searching a database of elements*. • Some pupils will need a good deal of help in planning what to do, but are likely to find it easier to explain what their results show. • Extension: pupils could try to find out what causes the loss in mass. They are likely to have used the lime water test for carbon dioxide in unit 7F 'Simple chemical reactions'. Some pupils could be challenged to think up alternative explanations for their evidence, *eg it lost mass because it combined with oxygen and made carbon dioxide, which escaped*, and how to decide between the explanations. It may be helpful with these pupils to introduce the symbol equation for the reaction. ⚠ **Safety** – copper carbonate is harmful. One product (copper oxide) is an irritant. Eye protection should be used. Teachers will need to check pupils' plans for health and safety, *eg that appropriate quantities are to be used,* before practical work begins