

## Unit 8F Compounds and mixtures

### About the unit

In this unit pupils:

- distinguish between elements and compounds and how they are represented by symbols and formulae
- recognise chemical change as a process in which atoms join together in new ways
- distinguish between compounds and mixtures
- distinguish between chemical reactions in which new compounds are formed and the formation of mixtures

In scientific enquiry pupils:

- decide how many measurements are needed for reliable results
- present data as graphs
- interpret and draw conclusions from observations and graphs
- investigate temperature changes as liquids cool

This unit is expected to take approximately 7.5 hours.

### Where the unit fits in

This unit builds on unit 8E 'Atoms and elements'.

Work on temperature, melting points and boiling points relates to unit 8I 'Heating and cooling'.

This unit relates closely to unit 7G 'Particle model of solids, liquids and gases' and to unit 7H 'Solutions'. However, if teachers wish to introduce the idea of particles through unit 8E 'Atoms and elements', this unit could be taught before unit 7G 'Particle model of solids, liquids and gases' and unit 7H 'Solutions'.

Ideas in this unit about mixtures are picked up in unit 8G 'Rocks and weathering' and unit 8H 'The rock cycle'.

Consideration of air as a mixture relates to unit 8B 'Respiration' and unit 9B 'Fit and healthy'.

This unit, together with unit 8E 'Atoms and elements', provides the foundation for unit 9E 'Reactions of metals and metal compounds', unit 9F 'Patterns of reactivity', unit 9G 'Environmental chemistry' and unit 9H 'Using chemistry'.

### Expectations

#### At the end of this unit

##### in terms of scientific enquiry

**most pupils will:** make observations and measurements of mass and temperature; present results as line graphs and interpret these using scientific knowledge and understanding

**some pupils will not have made so much progress and will:** make observations and measurements of mass and temperature and, with help, present these as line graphs

**some pupils will have progressed further and will:** explain how scales they chose for graphs enabled them to present results effectively; make suggestions of additional work to test conclusions of their investigations

##### in terms of materials and their properties

**most pupils will:** distinguish between elements, compounds and mixtures in terms of the particles they contain; name and describe some common mixtures and use knowledge about separation techniques to suggest how they might be separated; identify melting and boiling points as the fixed temperatures at which elements and compounds change state, and use the particle model to explain changes of state

**some pupils will not have made so much progress and will:** name some common elements, compounds and mixtures and distinguish between representations or models of these; describe how some mixtures could be separated and recognise changes of state in elements and compounds

**some pupils will have progressed further and will:** explain their criteria for classifying materials as elements, compounds or mixtures; represent some compounds by formulae and explain what these show about the numbers and types of atom present; describe how mixtures do not change state at fixed temperatures

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## Prior learning

It is helpful if pupils:

- can name some elements
- know that there are approximately 100 elements which are the building blocks for all materials
- know that elements are composed of tiny particles called atoms
- know that compounds are formed when atoms of different elements join
- have explored a number of chemical reactions
- have made and separated mixtures

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## Health and safety

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

- carry out a number of chemical reactions
- plan and carry out their own investigation of temperature changes

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.

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## Language for learning

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

- words with precise scientific meaning, *eg element, compound, mixture, atom, composition, pure*
- names of compounds, *eg sodium carbonate, calcium chloride, hydrochloric acid*

Through the activities pupils could:

- organise facts/ideas/information in an appropriate sequence
- group sentences into paragraphs which have a clear focus
- link ideas and paragraphs into continuous text that is organised and coherent

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## Resources

Resources include:

- cards showing the symbols of elements and compounds and corresponding descriptions
- labels from bottles of mineral water, showing composition
- samples of rocks that are mixtures
- samples of everyday materials that are mixtures, *eg milk powder, cola*
- sources of information, *eg video clips*, about the composition of air and the uses of its constituents, *eg British Oxygen leaflets*
- database software and other data sources showing melting points and boiling points of elements and compounds
- temperature sensor and software
- simulation software illustrating particles present in elements, compounds and mixtures

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## Out-of-school learning

Pupils could:

- look at labels on household materials and on clothes to find out what they are made from and to identify the names of chemical compounds

Pupils should learn:

Pupils:

### How are elements and compounds different?

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| <ul style="list-style-type: none"> <li>• that elements contain only one kind of atom</li> <li>• that compounds contain more than one kind of atom joined together</li> <li>• that formulae indicate the (relative) numbers of atoms in a compound</li> </ul> | <ul style="list-style-type: none"> <li>• Review and extend pupils' understanding of the difference between elements and compounds or non-elements by providing them with a series of cards, the first giving a description of appearance, the second the formula and the third the composition, <i>eg one atom of oxygen joined to two atoms of hydrogen</i>, and asking pupils in groups to match them in sets of three and to sort into elements and non-elements.</li> <li>• Make sure that pupils are clear that compounds contain atoms of more than one kind joined together.</li> </ul> | <ul style="list-style-type: none"> <li>• distinguish between elements and compounds</li> <li>• relate formulae to the numbers and types of atom in a compound</li> </ul> | <ul style="list-style-type: none"> <li>• If unit 8E 'Atoms and elements' and unit 8F 'Compounds and mixtures' are taught in a block, pupils may need to spend less time on these introductory activities. If they are not, teachers may need to provide a context in which ideas can be revisited.</li> <li>• If ionic compounds are included, it is sufficient to treat the formula as a ratio, <i>eg one atom of magnesium to one of oxygen in magnesium oxide</i>. It is important not to imply that ionic compounds consist of molecules.</li> </ul> |
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### How do compounds differ from the elements from which they are made?

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| <ul style="list-style-type: none"> <li>• that compounds contain elements that are chemically combined</li> <li>• that the properties of a compound are different from those of the elements from which it is made</li> <li>• that a compound always contains the same elements in fixed proportions</li> </ul> | <ul style="list-style-type: none"> <li>• Demonstrate making or invite pupils to make a mixture from two elements: sulphur (powder) and iron (powder). Ask pupils to heat a mixture of iron and sulphur in ignition tubes until they observe a red glow and, after their tube has cooled, to extract the contents and try to find out if it still contains a mixture or if a new chemical (compound) has been made. Through discussion of their results, establish that they have made a compound. Help pupils to write picture and word equations for the reaction.</li> <li>• Demonstrate that the compound iron sulphide behaves differently from its constituent elements sulphur and iron, <i>eg by adding a small amount of dilute acid to both and observing the differences in the way the mixture behaves compared to the compound</i>.</li> <li>• Ask pupils for names of compounds they have used, <i>eg water, carbon dioxide, copper carbonate</i>; provide them with samples and ask them to compare the compounds with the elements from which they are made. Establish, through discussion of the formulae of some of the oxides made in unit 8E 'Atoms and elements', <i>eg magnesium, sodium and aluminium oxides</i>, that compounds are made from elements in fixed proportions. Provide pupils with drawings or software simulations showing particles in examples of elements, compounds and various mixtures of elements and/or compounds. Ask them to identify the types of particles present and what the drawings represent in terms of elements, compounds and mixtures.</li> </ul> | <ul style="list-style-type: none"> <li>• describe differences between compounds and the elements from which they are made</li> <li>• interpret formulae for compounds in terms of the relative numbers of atoms of different elements</li> </ul> | <ul style="list-style-type: none"> <li>• Teachers may wish to draw pupils' attention to the red glow continuing after heat has been removed as evidence of an energy change as the chemical reaction takes place.</li> <li>• Extension: some pupils could try to make their own drawings starting from formulae or descriptions of composition.</li> </ul> <p><b>⚠ Safety</b></p> <ul style="list-style-type: none"> <li>– eye protection should be worn throughout. A 7:4 iron:sulphur mixture by mass should be used. The mixture can be heated in a small test tube with a mineral wood plug in its mouth. In the course of this activity, toxic and corrosive sulphur dioxide may be produced if the sulphur catches fire</li> <li>– when testing the product with dilute acid, eye protection should be worn and very small quantities used as hydrogen sulphide (toxic) and hydrogen (explosive) may be formed</li> </ul> |
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Pupils should learn:

Pupils:

### Do compounds react chemically?

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| <ul style="list-style-type: none"> <li>• to carry out test tube reactions</li> <li>• to identify observations relevant to a piece of work and draw conclusions from these</li> <li>• that compounds can react chemically</li> <li>• to organise ideas into an appropriate sequence</li> </ul> | <ul style="list-style-type: none"> <li>• Ask pupils to carry out a number of test tube chemical reactions in which visible changes occur, eg           <ul style="list-style-type: none"> <li>– <i>mixing sodium carbonate solution and iron (II) chloride solution</i></li> <li>– <i>adding dilute hydrochloric acid to solid magnesium carbonate</i></li> <li>– <i>adding dilute ammonia solution to copper sulphate solution</i></li> <li>– <i>heating sucrose</i></li> </ul> </li> <li>• Ask pupils to record their observations carefully, telling them that they are looking for evidence that chemical reactions making new materials have taken place. Ask pupils, in groups, to agree on a short paragraph about the reactions setting out the observations and evidence, then to exchange work and decide whether they agree or disagree with the evidence suggested, explaining their reasons.</li> </ul> | <ul style="list-style-type: none"> <li>• identify appropriate indications of chemical reactions</li> <li>• state that chemical reactions took place between the compounds</li> <li>• summarise what they observed and explain what this showed</li> </ul> | <ul style="list-style-type: none"> <li>• Pupils are likely to have explored chemical reactions in unit 7E 'Acids and alkalis' and unit 7F 'Simple chemical reactions'. This activity could be extended by asking pupils to think again about the evidence for a chemical reaction in the reactions explored in those units. Teachers may need to emphasise that some physical changes also involve colour changes and gas evolution, and that a chemical reaction is distinguished by changes in the ways the atoms are bonded together.</li> </ul> <p> <b>Safety</b> – 0.4 mol dm<sup>-3</sup> solutions should be used. At this concentration, the substances named are low hazard, but eye protection should be worn</p> |
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### Checking progress

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| <ul style="list-style-type: none"> <li>• to make connections between key ideas about chemical change</li> </ul> | <ul style="list-style-type: none"> <li>• Ask pupils to produce a concept map related to chemical change using terms, eg <i>atom, element, compound, burning, oxygen, formula, symbol, chemical, reaction, copper, oxide</i>. Discuss pupils' maps with them and if necessary help them to make an exemplar map to refer to in later work.</li> </ul> | <ul style="list-style-type: none"> <li>• link ideas in an appropriate way</li> <li>• recognise additional links when these are pointed out</li> </ul> | <ul style="list-style-type: none"> <li>• This activity and the next one are likely to show that pupils have a number of misconceptions. Some of these may be tackled by discussing pupils' ideas with them as they produce their concept map. Later activities in this unit, and activities in unit 9E 'Reactions of metals and metal compounds', unit 9F 'Patterns of reactivity' and unit 9H 'Using chemistry', provide further opportunities to revisit ideas about elements, compounds and chemical change.</li> </ul> |
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Pupils should learn:

Pupils:

### Are there other sorts of material besides elements and compounds?

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| <ul style="list-style-type: none"> <li>• about differences between compounds and mixtures</li> </ul>  | <ul style="list-style-type: none"> <li>• Remind pupils of work about mixtures in unit 7H 'Solutions' and show them examples of mixtures they may have encountered, <i>eg iron and sulphur, chalk in water, seawater, air, soil, rocks, ink, shaving foam</i>. Elicit what they understand by the term 'mixture', <i>eg by asking them to draw diagrams to illustrate the particles in elements and compounds and extending this to mixtures</i>, and establish their criteria for deciding whether something is a mixture or not. Introduce the idea that compounds can be represented by a formula whereas mixtures vary in composition, <i>eg by showing samples of compounds together with molecule models, and contrasting these with samples of mineral water together with labels from bottles showing that the water is a mixture</i>.</li> <li>• Ask pupils for their ideas of the meaning of 'pure' when applied to a material, <i>eg What is 'pure' orange juice? What is 'pure' water?</i> Establish what is meant by 'pure' and 'impure' and link back to the illustrations of elements, compounds and mixtures made earlier in the activity. Reinforce using simulation software illustrating elements, compounds and mixtures.</li> </ul> | <ul style="list-style-type: none"> <li>• name some everyday mixtures, <i>eg air, seawater, mineral water</i></li> <li>• identify that mixtures can vary in composition</li> </ul>   | <ul style="list-style-type: none"> <li>• Pupils will have had opportunities to make and separate some mixtures in unit 7H 'Solutions'.</li> <li>• The idea of rocks as mixtures is explored more fully in unit 8G 'Rocks and weathering' and unit 8H 'The rock cycle'. It would be helpful to use the same rock samples in this activity.</li> </ul>  |
| <ul style="list-style-type: none"> <li>• that air is a mixture of gases</li> <li>• that air can be separated into its constituents</li> <li>• to group sentences into paragraphs which have a clear focus</li> <li>• to link ideas and paragraphs into continuous text</li> </ul> | <ul style="list-style-type: none"> <li>• Ask pupils how a mixture of a solid and liquid, <i>eg blue ink</i>, or of coloured dyes, <i>eg inks in a felt-tip pen</i> can be separated. Use secondary sources, <i>eg video clips</i>, to illustrate that air is a mixture and ask them why it might be important to separate the gases in air. Provide pupils with appropriate information about the separation of air into its components and the uses of these. Extend the work, as appropriate, by asking them to find out differences between inhaled and exhaled air, the importance of ventilation in rooms, how the composition of air dissolved in water varies and about the composition of air in passenger planes. Ask pupils to produce an information leaflet about air reminding them about the importance of organising facts, ideas and information into sentences, which are then grouped into paragraphs with appropriate linkages.</li> </ul>   | <ul style="list-style-type: none"> <li>• name the main gases present in air and give approximate proportions of these</li> <li>• explain clearly how air can be separated into its components</li> <li>• describe clearly some uses of the components of air</li> <li>• sequence and organise ideas into coherent, continuous text</li> </ul> | <ul style="list-style-type: none"> <li>• It may be helpful to use this activity with some pupils to reinforce the idea that some of the gases in air consist of single atoms, while others are molecules.</li> <li>• This relates to work on photosynthesis and respiration in unit 8B 'Respiration', unit 9B 'Fit and healthy' and unit 9C 'Plants and photosynthesis', and to work on air pollution in unit 9G 'Environmental chemistry'.</li> <li>• This activity provides an opportunity to use ICT for producing the leaflet.</li> </ul> |

**Learning objectives**

Pupils should learn:

- that elements and compounds melt and boil at particular temperatures
- that mixtures do not melt or boil at fixed temperatures
- to use data from secondary sources

**Possible teaching activities**

- Ask pupils to look back at the work they did on elements in unit 8E 'Atoms and elements' and to identify boiling points and melting points of some of these elements. Illustrate with video clips the very high temperatures at which some metals melt. Establish, through discussion of their data and other data from secondary sources, that changes of state of pure elements and compounds occur at a fixed temperature and that the temperature is a characteristic of the material that is changing state.
- Give pupils examples of melting points and boiling points. Ask them whether boiling point is always higher than melting point and help them to use database software to test their predictions. Establish through discussion that melting and freezing are opposites and occur at the same temperature for a given material. Illustrate with video clips that gases can be cooled enough to liquefy and may eventually solidify. Relate this back to work on separation of air.
- Ask pupils if they can find in any data book or database the boiling point of air and to explain why they cannot. Carry out a quick demonstration of the differences in the boiling point of tap water and salt solution and introduce the idea that mixtures do not have fixed melting or boiling points.

- to decide how many measurements to make
- to relate results to scientific knowledge and understanding
- to consider whether there was other evidence they could have collected

- Provide pupils with two liquids labelled A and B (distilled water and salt solution). Tell them that they are going to investigate how temperature changes as they cool (surrounded by an ice/salt mixture) and use this and any other sample tests to find out as much as possible about the liquid. Ask the pupils to plan what to do, including how frequently they will make measurements, and to produce an account of what they did, tables and graphs of results and to use all their results to draw conclusions about the liquids.

**Learning outcomes**

Pupils:

- identify the melting and boiling points of a range of elements and compounds
- explain that these are characteristic of the element or compound
- describe how the melting point or boiling point of a mixture varies with composition

- identify differences between the graphs and explain that these show one is a pure liquid and the other is not
- suggest additional tests, *eg evaporating both liquids, finding the boiling point of both liquids*, explaining what these might show

**Points to note**

- Pupils will have constructed a temperature line in unit 8I 'Heating and cooling'. They could add some of the melting points and boiling points considered in this activity. At this stage it is not necessary to consider variation of boiling point with atmospheric pressure unless pupils raise the question.
- If it is possible to obtain a sample of liquid nitrogen, demonstration of its properties provides additional interest and challenges pupils' thinking.



**Safety** – ensure liquid nitrogen is transported safely in a properly sealed Dewar flask. Beware cold burns. Obtain a special risk assessment

- Pupils are likely to need guidance on how to use the ice/salt mixture. A good supply of ice will be needed for class investigations.
- A temperature sensor attached to a computer could be used in this activity
- As an additional or alternative activity, some pupils could investigate the cooling of pure and impure stearic acid.
- In unit 8I 'Heating and cooling', pupils investigate temperature changes as ice and salol melt and freeze. They could be reminded of this work.



**Safety** – teachers will need to check pupils' plans for health and safety before practical work begins

Pupils should learn:

Pupils:

### Reviewing work

- about key differences between elements, mixtures and compounds
- Give pupils a list of statements, eg
  - *is made up of atoms*
  - *has a definite composition*
  - *is a result of atoms joining together*
  - *contains different substances which are not chemically combined*
  - *can be represented by a chemical formula*Ask them to assign each to one or more of element, compound and mixture.
- Some pupils will also be able to sort the statements in each category so that similar ones are grouped together. Check those that apply to two or to all three, eg *contains molecules*, and those which are 'difficult', and agree a summary sheet consisting of correctly allocated statements. Ask them to add familiar examples of elements, compounds and mixtures to their summary sheet.
- identify characteristics of elements, compounds and mixtures, explaining the basis for their decisions
- Extension: for some pupils more complex statements could be used, eg *contains some substances with a definite composition*.
- This activity extends the first part of the 'reviewing work' activity at the end of unit 8E 'Atoms and elements'. It may be helpful to use the same statements, together with additional ones, and ask pupils whether they feel more confident in assigning the statements.