Unit 9H Using chemistry

About the unit

In this unit pupils:
- find out more about how chemical reactions can be used as an energy source
- consider how chemical reactions are used to make new materials
- model chemical reactions as the rearrangement of atoms, and use the model to explain that matter is not lost
- represent chemical reactions by word and/or symbol equations

In scientific enquiry pupils:
- consider how the particle model and knowledge of gases helped change earlier ideas about burning
- consider how scientists work together to develop a new product
- make observations and measurements of temperature, mass and voltage
- investigate changes in mass when magnesium burns

This unit is expected to take approximately 7 hours.

Where the unit fits in

This unit builds on unit 9E ‘Reactions of metals and metal compounds’ and unit 9F ‘Patterns of reactivity’. It relates to other units, particularly to aspects of photosynthesis and respiration in unit 8B ‘Respiration’ and unit 9C ‘Plants and photosynthesis’, and to units about energy – unit 8I ‘Heating and cooling’ and unit 9I ‘Energy and electricity’.

This unit provides opportunities to revisit and revise topics met in other units in years 7 and 8. With some pupils, teachers may wish to concentrate on some of the new topics, extending activities, and with others to spend more time on revision of previous work.

This unit provides the foundation for work in key stage 4 on using chemical reactions to make new materials.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: make measurements of temperature and mass adequate for the investigation they are carrying out; describe some of the stages in development of a new product

some pupils will not have made so much progress and will: make measurements of temperature and mass; identify some products that have recently been developed

some pupils will have progressed further and will: explain the stages of development of a new product

in terms of materials and their properties

most pupils will: describe how chemical reactions are used to make new products and as a source of energy; use the particle model to explain how mass is conserved during chemical reactions and other changes; represent chemical reactions by word equations

some pupils will not have made so much progress and will: name some products produced by chemical reactions and identify burning as a reaction which produces energy

some pupils will have progressed further and will: reconcile observations in which mass appears to be lost with the principle of conservation of mass, and represent some reactions by symbol equations

Prior learning

It is helpful if pupils:

- have carried out a test for carbon dioxide
- know that burning involves a reaction with oxygen in which oxides are formed
- know that new materials are formed when chemical reactions occur and can identify evidence of these
- have used symbols and formulae and word and/or symbol equations
- recognise an order of reactivity of metals

Health and safety

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

- use flammable liquids and solutions which may be hazardous
- observe some reactions between elements
- use gas syringes
- observe burning magnesium

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:

- chemical names of a range of compounds, understanding the significance of prefixes, *eg di-, mono-, poly-*, and suffixes, *eg -oxide, -ate*
- words and phrases relating to scientific enquiry, *eg development of product, trial, quantitative data*

Resources

Resources include:

- secondary sources, *eg video, CD-ROMs,* illustrating the burning of a range of fuels, *eg household waste in a power station*
- equipment for making simple voltaic cells
- information about chemical heaters, *eg meals for climbers, hand warmers for Arctic explorers*
- secondary sources or artefacts illustrating a range of materials, *eg textiles, plastics, pharmaceuticals, toiletries, processed foods*
- case histories illustrating the development of a new product, *eg vacuum cleaner, food product*
- simulation software illustrating the rearrangement of atoms in chemical reactions
- secondary sources providing information about Priestley, Lavoisier and earlier ideas about burning

Out-of-school learning

Pupils could:

- note newspaper and news articles about fuels, their advantages and disadvantages and impact on the environment
- compare the sodium chloride content of common foods
- look at labels on salt used for different purposes, to find out whether it is pure sodium chloride

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What chemical reactions take place when fuels burn?			
• that fuels burn and release energy • that when fuels containing hydrogen and carbon burn, water, carbon dioxide and sometimes carbon monoxide and carbon are formed • to evaluate advantages and disadvantages of a fuel	• Show pupils a video/video clip or other secondary sources of a range of fuels burning, and ask them what they recall about the sort of materials that are fuels and what is made when they burn. Demonstrate products (carbon dioxide and water) of burning natural gas. Ask pupils to explore, using secondary sources and practical work, what is formed when other fuels containing hydrogen and carbon, *eg ethanol, wax, wood,* burn. • Establish the products of complete combustion as carbon dioxide and water, and that soot and carbon monoxide can also be formed. Extend by asking pupils to find out about the use of hydrogen as a fuel and its advantages and disadvantages.	• identify a range of fuels and describe fuels as substances that release energy when they burn • generalise about the products of burning fuels that contain hydrogen and carbon • balance advantages of hydrogen as a fuel, *eg produces no carbon dioxide, light,* against disadvantages, *eg highly explosive if mixed with air, needs to be compressed for storage*	• These two activities are designed to help teachers find out what pupils recall from earlier units and to revise and consolidate key ideas. • Pupils will have had opportunities to burn a range of fuels (including foods) in unit 7I 'Energy resources' to compare the energy released. They will also have considered energy values of foods in unit 8A 'Food and digestion', and burning as a reaction resulting in the formation of oxides in unit 7F 'Simple chemical reactions'. Oxides are also covered in unit 9E 'Reactions of metals and metal compounds'. This activity is designed to revisit and reinforce these ideas. • Extension: pupils could be asked to find out about the dangers of carbon monoxide. Pupils' attention could be drawn to the different properties of carbon monoxide and carbon dioxide and the fact that they are different compounds, as shown by their formulae. ⚠ **Safety** – care is needed to control flames. If ethanol or other flammable liquids are burnt, very small quantities should be used. The fuel containers should be kept stoppered and well away from flames. Petrol must never be used
• to apply knowledge and understanding of burning to an everyday context	• Tell pupils that the chemicals found in match heads are potassium chlorate, sulfur and carbon and give them a series of questions to answer, *eg* – *Which of these are elements?* – *What is the formula for potassium chlorate?* – *What is its role?* – *How does striking a match produce heat?* – *What burns?* Ask pupils to explain their answers.	• describe the role of the sulfur, carbon and potassium chlorate in the match head • explain how the match produces a flame	• It may be helpful to point out that compounds with names ending in '-ate' contain oxygen.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How else are chemical reactions used as energy resources?			
• that displacement reactions involving metals produce energy • that the energy from these reactions can be used • to link energy produced in displacement reactions to differences of reactivity of metals	• Ask pupils to suggest other examples of situations in which chemical reactions are used as energy resources. If necessary, remind them of the thermit reaction. Demonstrate or ask pupils to explore the generation of a voltage from simple voltaic cells. Remind them of the reactivity series of the metals and ask them to predict pairings of metals that will give relatively high and low voltages and to test their predictions. • Remind pupils of their investigation of the reactivity of magnesium and zinc in unit 9F 'Patterns of reactivity', and ask them to carry out quick test-tube reactions to compare the temperature changes when different metals are added to solutions of a salt, *eg copper sulfate*, ensuring they make a reasonably fair comparison. Discuss results with pupils, record word equations and, where appropriate, symbol equations for the reactions, and the key points relating energy produced to differences in reactivity.	• describe chemical reactions that are used to produce energy • relate the energy produced to differences in reactivity, *eg magnesium and copper are further apart in the reactivity series than iron and copper, so more energy will be produced*	• The thermit reaction is included in unit 9F 'Patterns of reactivity', and chemical cells are covered in unit 9I 'Energy and electricity'. • Extension: pupils could be asked to find out about the chemical reactions in some cells. Details are not needed; the work is to establish the principle that energy comes from the reactions. ⚠ **Safety** – use 0.4 mol dm^{-3} copper sulfate solution
• that other chemical reactions can be used as sources of energy • about ways in which these reactions can be used • about the effect of different aspects of formality in writing, *eg passive verbs, third person, abstract nouns*	• Extend ideas about using energy from chemical reactions by asking pupils to use secondary sources to find out about 'chemical heaters' for meals or hand warmers for climbers and explorers. • Ask pupils to think about the type of reactant and reactions that would be effective and safe and discuss this with them. Provide them with the reactants to explore energy produced by some of these reactions. Ask pupils to draw up a specification for making a 'chemical heater' or an advertisement for a heater. Before they do so, ask pupils to think about the different ways in which similar information would be used in the two tasks. Help pupils to compare a specification and an advertisement and identify and explain why the formality of the writing is different in each case.	• describe ways in which some chemical reactions can be used • identify and explain differences between objective and more persuasive writing	• Reactions used include the reaction of iron (III) oxide and iron with water. • It may be helpful to show pupils an endothermic reaction, *eg sodium hydrogencarbonate and citric acid,* to ensure they do not think all reactions are exothermic.
What types of new material are made through chemical reactions?			
• about the range of materials made through chemical reactions • about the stages of development of a new product	• Use photographs, packaging, video material to illustrate to pupils the vast range of materials, including those in living systems, resulting from chemical reactions. If possible, invite a scientist, *eg pharmacist, materials scientist, food scientist,* to talk to pupils about what they do and how they develop new products. Supplement this by providing pupils with case studies of the development of a new product, *eg drug, plastic, textile, foodstuff*. Ask pupils to choose a product and make a summary of the key stages of development.	• name a range of materials in living and other systems resulting from chemical reactions • describe the key stages of development of a new product	• Some schools may be able to arrange a visit to an appropriate workplace. It may be helpful to ask pupils to prepare questions to ask before any visit. • Information can be obtained from a range of sources, *eg publications of the Royal Society of Chemistry and the Chemical Industry Education Centre at the University of York*.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Checking progress			
• how chemical reactions are used	• Provide pupils with statements, *eg* – *Chemical reactions can be used as energy resources* – *Chemical reactions are used to make new materials* – *Chemical reactions are important in biological systems* • Give pupils a variety of information, *eg description of photosynthesis, description of a plastic, diagram of a voltaic cell, word equations, symbol equations,* and ask them to agree to which statement each piece of information is best assigned, and to identify whether any can be assigned to more than one category. Help pupils to make a summary illustrating the important uses of chemical reactions in everyday situations.	• identify the uses of particular chemical reactions • describe the range of uses of chemistry in everyday situations	• This activity provides the opportunity to draw in other aspects of chemical reactions for revision and consolidation.
What happens to atoms and molecules when new materials are made?			
• to use preliminary work to decide on appropriate apparatus • that mass is conserved in chemical reactions • that atoms combine in different ways as a result of chemical reactions	• Demonstrate some reactions in which a change can be clearly observed, *eg production of a precipitate, change in colour, perceptible rise in temperature,* but in which no gas is produced, and help pupils to devise a method for finding out whether there is a change in mass when the reaction takes place. Establish that mass is conserved. • Take some examples of reactions, *eg burning hydrogen; burning carbon to form carbon dioxide and to form carbon monoxide; combining hydrogen and chlorine,* and model the rearrangement of atoms in these using, *eg ball-and-spoke models, simulation software.* Establish with pupils that atoms 'left over' cannot disappear. • Help pupils to explain conservation of mass in terms of the rearrangement of the atoms during a reaction.	• devise a method of finding out whether mass is conserved in a reaction • use models to describe the conservation of mass in a reaction • use models or simulations to show how atoms combine in different ways as a result of a reaction	• It may be helpful to model reactions that do not include ionic compounds. • Reactants can be kept apart using an ignition tube suspended by a thread in a stoppered flask. ⚠ **Safety** – safety screens and eye protection should be used if these reactions are demonstrated. A jet of hydrogen can be burnt in a glass jar of chlorine, but hydrogen and chlorine should not be mixed in a container. Employer's risk assessments should be followed
• that when gases are formed in reactions, mass may appear to decrease because the gas escapes • that mass is also conserved in dissolving and changes of state	• Challenge pupils to decide whether mass would be conserved during a reaction in which a gas was made and, if possible, demonstrate this, *eg by collecting gas in a syringe.* Provide pupils with a number of descriptions of burning, *eg it all turns into ash, nothing is left, the wood just shrivels away*, and ask them to reconcile these with the idea of conservation of mass.	• recognise that mass is conserved in reactions in which gases are produced • explain the apparent loss in mass in reactions involving the production of gases	• Extension: pupils could be asked to apply their ideas of conservation of mass to the reactions of respiration and photosynthesis. ⚠ **Safety** – teachers need to ensure that pupils can use gas syringes safely if they participate in the demonstration

Learning objectives Pupils should learn:	**Possible teaching activities**	**Learning outcomes** Pupils:	**Points to note**
• that the oxide weighs more than the element from which it was made • to plot a graph and use it to obtain quantitative data • that predictable masses of the oxide can be formed from given masses of magnesium	• Remind pupils of work they did earlier about making compounds from elements. Either demonstrate or ask pupils to find the increase in mass when magnesium burns in air. Compile a set of results from the class or provide pupils with a set of results and help them plot a graph of mass of magnesium oxide against mass of magnesium. Ask pupils a series of questions to elicit their ideas about what has happened, *eg* – *Why does the magnesium oxide weigh more than the magnesium?* – *How much magnesium oxide is formed from 1g/1.5g of magnesium?* – *How much magnesium oxide do you think would be formed from 10g/15g of magnesium?* – *Do these results conflict with the idea of conservation of mass?*	• state that the mass of magnesium oxide is greater than the magnesium, and explain this in terms of combination with oxygen • recognise the relationship shown in the graph, and use this to predict how much magnesium oxide will be made from other starting masses of magnesium	• Pupils will need a considerable amount of help if they are to get reasonable results from this activity. A prepared set of results will enable pupils to identify the linear relationships. These could be presented on a spreadsheet. It is more interesting to use class results and discuss why they may not show the linear relationship. • Some pupils will be ready to appreciate that the mass of oxide formed can be predicted because magnesium oxide contains magnesium and oxygen atoms in the ratio 1:1. Others will simply appreciate why magnesium increases in mass. **Safety** – eye protection should be used. Crucibles remain hot for some time and should be left to cool on tripods
• that carbon dioxide and water are formed when a compound containing both carbon and hydrogen is burned • that the carbon dioxide and water formed escape into the atmosphere • that mass is conserved when materials burn • to select relevant information and link it to other information • that sometimes new evidence requires changes to theories	• Show pupils a wax candle burning and pose a question, *eg If materials combine with oxygen when burning, why does a candle get smaller and smaller?* Provide pupils with additional information, *eg wax is a compound of carbon and hydrogen*, and ask the pupils to suggest what is formed when it burns. Establish with pupils what is likely to be formed when hydrocarbons are burned and ask them to suggest what happens to the products. • Represent the formation of carbon dioxide and water by word equations and/or diagrams. Extend to a range of compounds containing hydrogen and carbon, *eg natural gas, sugar*. • Provide pupils with information about Priestley, Lavoisier and the phlogiston theory of burning, together with a series of questions of various difficulty, *eg* – *What did Priestley find out about oxygen?* – *What was the phlogiston theory?* – *What did Lavoisier contribute to the development of ideas about burning?* • Ask pupils to describe what they found out and discuss with them eighteenth-century ideas about burning and how these differ from those we hold today. Ask them how our ideas about particle theory help to explain our views.	• state that carbon dioxide and water are formed when, *eg wax, natural gas*, is burned • explain that the water and carbon dioxide formed escape into the air • explain that if the carbon dioxide and water could be collected, there would be no loss of mass • represent the reactions by word or symbol equations or diagrammatically • identify from texts answers to questions posed • summarise evidence about burning • describe how eighteenth-century ideas about burning differ from those we hold today and summarise the evidence for present-day ideas	• Pupils may have found out about Priestley and Lavoisier in unit 7F 'Simple chemical reactions'.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Reviewing work			
• to recognise the variety in chemical reactions • to make some generalisations about reactions	• Provide pupils with word equations and/or symbol equations, general equations and descriptions of reactions, *eg neutralisation, combination with oxygen, displacement,* and ask them to group together similar reactions. Include some that don't fit into any category. Discuss these and the classifications with pupils and agree with them a short list of key points about reactions, *eg* – *new materials are made* – *atoms combine in different arrangements* – *evidence for reaction includes …* – *mass is conserved because atoms link together in different ways* – *chemicals are an energy resource because energy is often released when reactions occur*	• match word equations to descriptions of reactions and/or symbol equations • group together some reactions of a similar type • identify key points about reactions	