



Fusion 3: C2.1 – Chemical Reaction		
National Curriculum Link up •3.2 b and c, 3.4c		
Learning Objectives Pupils should learn: The difference between a reversible and irreversible change. The difference between a chemical reaction and a physical change. How to record a chemical change.	Teaching / Learning activities Lesson structure Starter – What a state Ask pupils to list the properties of solids, liquids and gases. You could extend this by asking them to draw how the particles are arranged and link the properties to the arrangements. (10 mins) Main Start the lesson by discussing what pupils think the words 'reversible' and 'irreversible' mean. Try to ensure that pupils are clear that 'reversible' describes a change in which no new substances are formed and that 'irreversible' describes a change in which new substances are formed. Remind pupils that changes to materials can be reversible or irreversible. Ask pupils to carry out the 'Classifying changes' activity described in the pupil book. Once they have completed the observing part of the activity, ask them to work in small groups to complete the table. They should be encouraged to discuss their opinions and to come up with reasons for ticking the columns they choose. Share the results as a class and establish that adding sodium chloride to ice melts it, which is a reversible, physical change as the salt can be separated from the water and then the water can be refrozen. Adding magnesium to acid is an irreversible chemical change, as there is a reaction which forms two new substances: hydrogen and magnesium chloride. Warming iodine causes it to sublime and become gaseous. Upon cooling it will solidify again, often forming crystals as it does, so this is a reversible change. Plenary - Physical or chemical? Ask pupils to list what they might observe during a chemical change. [The list may include: gas formation/ fizzing, colour change, temperature change, emission of light, though none of these on their own is absolute proof of a chemical change.] (5 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. You may wish to tell the pupils which changes are reversible and which are irreversible before they start the practical activity. The challenge for pupils would then be to look for evidence to support this. • Extension. Allow pupils to heat some zinc oxide in a test tube and let them decide whether it is a reversible or irreversible change. When zinc oxide is heated it changes colour from white to yellow, suggesting a chemical and irreversible change. On cooling, it turns white again. The change is physical and reversible. • Learning styles. <i>Visual:</i> Observing changes. <i>Auditory:</i> Discussing the results of the activity in small groups. <i>Kinaesthetic:</i> Carrying out practical work. <i>Interpersonal:</i> Sharing their ideas and evidence with other pupils. <i>Intrapersonal:</i> Understanding the difference between a reversible and an irreversible change.
Learning Outcomes <i>All pupils should be able to recognise a reversible and an irreversible change.</i> <i>Most pupils should be able to explain why a change is reversible or irreversible.</i> <i>Some pupils should also be able to write equations for the reactions they have seen.</i>	Additional teachers notes Equipment and materials required Per group: 100 cm ³ beaker, 50 cm ³ crushed ice, 20 g of sodium chloride, spatula, glass rod, test tube and rack, 5 cm ³ of 0.5 mol/dm ³ hydrochloric acid, 1 cm strip of magnesium ribbon, eye protection, test tube: sealed and containing ¼ spatula of iodine crystals. Access to hot water (maximum 50°C). Water can be running, as suggested in the pupil book, or in a beaker. Safety. Wear eye protection. Test tubes containing iodine vapour should not be opened. Iodine is harmful: CLEAPSS Hazcard 54A. Hydrochloric acid: CLEAPSS Hazcard 47A. Extension: Heating zinc oxide - Equipment and materials required Per group: Bunsen burner, heat-proof mat, matches, test tube, test tube holder, 1 spatula of zinc oxide, eye protection. Safety. Ensure the open end of the test tube is not pointing at anyone. Wear eye protection. Zinc oxide: CLEAPSS Hazcard: 108B.	



Fusion 3: C2.2 - Combustion		
National Curriculum Link up •3.2b		
Learning Objectives Pupils should learn: What combustion is? What the combustion products of wax are.	Teaching / Learning activities Lesson structure Starter - Fire, fire Ask pupils to recall and sketch the fire triangle and explain its significance [The sides of the fire triangle are: fuel, oxygen and heat . Removing one of the 'sides' will cause the fire to go out.] (5 mins) Main Remind pupils of the work they have done in the past on burning and the fire triangle. Establish combustion is the reaction between a fuel and oxygen. Some pupils may say that 'air' is needed for combustion so this is an ideal opportunity to discuss the fact that air is a mixture gases, including oxygen. Burn a candle in front of pupils. Explain that the wax is the fuel for the candle and that it is a 'hydrocarbon' fuel which contains the elements hydrogen and carbon. Ask pupils for evidence that a chemical reaction is taking place. [Light and heat and the fact that it is not easily reversed.] Remind pupils that if a chemical reaction is taking place, new substances must be formed. Demonstrate the collection and testing of the products of combustion. Establish that both water and carbon dioxide are formed during the combustion of a hydrocarbon fuel. Explain that gas, petrol and diesel are other examples of hydrocarbon fuels. Explain how carbon dioxide and water (hydrogen oxide) are formed when carbon and hydrogen in the fuel react with oxygen. Help pupils to build up the word equation for combustion [hydrocarbon fuel + oxygen → carbon dioxide and water]. You could represent the changes using molecular models if you have them available, showing the fuel molecule breaking up and the carbon dioxide and water forming. [$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$, methane (CH_4) is the main compound in natural gas.] You could also extend higher attaining pupils by using the models to develop symbol equations. Plenary - Burning question Ask pupils to consider how the products of combustion would be different when charcoal is burned. They should explain their answer. [Charcoal is almost pure carbon so the only product would be carbon dioxide.] (10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. The derivation of the word equation may be above the level of some pupils. However, the word equation for combustion can be learned by rote. • Extension. Ask pupils to research the causes of incomplete combustion and why it is dangerous. • Learning styles Visual: Observing combustion and the visual tests for carbon dioxide and water. Auditory: Describing the outcomes of the tests for water and carbon dioxide. Homework. Pupils to find out about the safety suggestions for gas appliances in the home, especially those which guard against incomplete combustion.
Learning Outcomes <i>All pupils should be able to state that combustion is the burning of a fuel in oxygen.</i> <i>Most pupils should be able to state that the products of the combustion of a hydrocarbon are carbon dioxide and water.</i> <i>Some pupils should also be able to explain how cobalt chloride paper indicates the presence of water.</i>	Additional teachers notes Equipment and materials required Demonstration apparatus: candle, sand tray, glass funnel, side-arm 'U' tube with two one-holed bungs in the top, cobalt chloride paper or anhydrous copper sulfate powder, beaker of ice, boiling tube and two-holed bung, limewater, tap suction pump, delivery tubing to link the system together, eye protection. Safety Wear eye protection. Avoid skin contact with cobalt chloride paper if possible. Cobalt chloride: CLEAPSS Hazcard 25. Limewater is an irritant: CLEAPSS Hazcard 18.	



Fusion 3: C2.3 – Energy from fuels		
National Curriculum Link up •1.1b, 2.1a, 3.2b		
Learning Objectives Pupils should learn: What a fuel is. How to find out how much energy a fuel can transfer.	Teaching / Learning activities Lesson structure Starter - Let's investigate Give pupils some key words related to investigations, such as 'dependent variable', 'independent variable', 'fair test' or 'anomalous result', and ask them to write definitions for them. (10 mins) Main Remind pupils of the work they did about fuels last lesson. Remind them that when a hydrocarbon fuel burns it reacts with oxygen to produce water and carbon dioxide. Ask them why we burn fuels and establish that burning fuels transfers energy which we can use. Ask pupils to suggest how we could measure the amount of energy released by a fuel. They will often suggest measuring the temperature of the flame, but this is not a measure of the total energy released as much of the energy will not be transferred to the thermometer. You could explain that you are far more likely to get a burn from a cup of hot tea than from a spark, to dispel this misconception. Even though a fire spark has a very high temperature, it does not have much energy. Establish that to measure the heat transferred in burning a fuel, the energy must be transferred to something, like water, before it can be measured. Ask pupils to carry out the ' How much energy is in the fuel? ' experiment, described in the pupil book. You may wish to have a discussion about fair testing before the pupils make a start, especially if you plan to share results to save time. The method given is a sound suggestion. However, if you have time you may wish to give pupils more freedom to alter the variables, particularly the amount of water, the time and temperature rise. [Too little water and/or too long a time period and there is more chance of the water boiling. As the water boils, its temperature will stop rising and we cannot easily establish how much energy has been transferred. Large temperature rises lead to greater energy loss from the water. It is losing energy to the surroundings throughout the experiment; the greater the temperature differences between the water and the surroundings, the faster the loss. If the amount of water is too large or the time too short, the water temperature will not change very much making it very difficult to compare fuels.] Plenary - Fuel for thought Give pupils data about the energy released by other fuels and ask them to consider which one is 'best'. You could include some solid, liquid and gaseous fuels and ask pupils to define what 'best' means. (5 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. The fuels can be compared at a very simple level by looking at the temperature rise and making the assumption that the same amount of fuel is used if the burners are alight for the same amount of time. • Extension. You can extend higher attaining pupils by asking them to calculate accurately the amount of energy transferred to the water. • Learning styles Visual: Observing data-logging graphs, if loggers are used for the experiment. Auditory: Describing the sources of error in the fuels experiment. Kinaesthetic: Carrying out the fuels investigation. Interpersonal: Evaluating the experiment in groups. Intrapersonal: Understanding the idea that some of the energy from the fuel is 'lost'. <ul style="list-style-type: none"> • Homework. Complete the write-up of the fuels investigation.
Learning Outcomes <i>All pupils should be able to state that burning fuels releases energy.</i> <i>Most pupils should be able to describe how burning some fuels releases more energy than others and how to measure this using the temperature rise of water.</i> <i>Some pupils should also be able to explain how to make a detailed comparison of energy transferred using energy gained by water against mass of fuel used.</i> How Science Works Explain how the planned approach to answer a scientific question was informed by scientific knowledge, understanding or other sources of evidence. (1.2a)	Additional teachers notes Equipment and materials required - Per group: 3 spirit burners, each containing a different liquid fuel, such as ethanol, propanol and butanol, retort stand, boss and clamp, 250 cm ³ beaker, 150 cm ³ of cold water per run (may need to adjust depending upon heat output of your spirit burners, balance, measuring cylinder for water, thermometer, matches, stopwatch, electronic balance (optional for extension if pupils are to consider mass of fuel burned), eye protection. Safety - Wear eye protection. The fuels are highly flammable. See CLEAPSS laboratory handbook/CD-Rom section 9.4.3 and Guide L195. Ethanol is harmful and highly flammable: CLEAPSS Hazcard 40A. Propanol is highly flammable and an irritant: CLEAPSS Hazcard 84A. Butanol is harmful: CLEAPSS Hazcard 84B.	



Fusion 3: C2.4 – What's the damage? (2)		
National Curriculum Link up •1.2b, 3.2b, 3.4c		
Learning Objectives Pupils should learn: How the combustion of fuels might affect the environment. The difference between the greenhouse effect and global warming.	Teaching / Learning activities Lesson structure Starter - What global warming anyway? Ask pupils to describe what they think global warming is all about. Don't give them any clues at this stage. It will allow you to note any misconceptions they have learned from the media. (5 mins) Main A good way to start this lesson is to suggest to pupils that scientists can't yet explain everything (How Science Works). There are many things which happen naturally which people cannot yet explain. We can't even cure the common cold! Pupils may well have studied the health effects of smoking and be aware that, initially, nobody realised that smoking was dangerous. Introduce the idea that many human activities can have consequences later on. Pose the question about what happens to the products of combustion in our atmosphere. Ask pupils to set up the investigation 'Effects of carbon dioxide and methane on temperature', described in the pupil book. This experiment could be data-logged, as the pupil book suggests, or you could use manual thermometers. The experiment needs to be left for a while. During that period, discuss the fact that that some acidic gases are released by the burning of fossil fuels. Explain that, when acidic gases dissolve into the water droplets that make up clouds, they make the rain that falls acidic. This can damage the environment. Show pupils photographs of the damage acid rain can cause. When you return to the gas experiment, pupils should find that the methane and carbon dioxide flasks have a higher temperature than the air-filled flask, because they retain more of the heat energy absorbed from the Sun. Plenary - Can we fix it? Ask pupils to work in small groups to suggest ways of reducing the effects of acid rain and the human contribution to global warming. (10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Give pupils cards with facts about global warming and acid rain on to sort into two groups. The many stages in both global warming and acid rain make the process quite conceptual. You may wish to stick to the concrete aspects of both, such as their effects. • Extension. Pupils could be asked to investigate the effects of acid rain. They could test 'rain water' with different gases in to establish which is the most acidic. They could then investigate how oxides of nitrogen and sulfur get into the atmosphere. • Learning styles Visual: Looking at pictures of the damage caused by acid rain. Auditory: Describing the greenhouse effect and acid rain. Kinaesthetic: Carrying out the investigation into the greenhouse effect. Intrapersonal: Understanding that the side-effects of chemical reactions are not always immediately apparent, nor do they always occur locally. • Homework. Ask pupils to write a newspaper article for the future, after the Earth's temperature has risen by 10°C.
Learning Outcomes <i>All pupils should be able to state that many scientists believe that carbon dioxide is causing global warming.</i> <i>Most pupils should be able to explain that carbon dioxide traps heat energy in our atmosphere and increasing the amount of carbon dioxide might lead to global warming.</i> <i>Some pupils should also be able to explain whether or not they think global warming is caused by carbon dioxide or something else.</i> How Science Works Evaluate the issues, benefits and drawbacks of scientific developments with which they are familiar. (1.1b)	Additional teachers notes Equipment and materials required. Per group: three 200 cm ³ conical flasks, 3 temperature probes and data-logger or 3 thermometers, 3 bungs with single hole to accept temperature probe or thermometer (must seal around it). Access to supply of carbon dioxide. Access to supply of methane, for example laboratory gas supply which is approximately 75% methane. Safety. Methane is extremely flammable: CLEAPSS Hazcard 45A.	



Fusion 3: C2.5 - Oxidation		
National Curriculum Link up •3.2b		
Learning Objectives Pupils should learn: What oxidation is? What the product of oxidation is.	Teaching / Learning activities Lesson structure Starter - Shelf life Show pupils a selection of food packets. Ask them to sort the foods into groups based on their shelf life. At its simplest, this could be just two groups: foods with a very short shelf life and those with a long shelf life. You could also ask pupils to suggest why those foods have short or long shelf lives. (10 mins) Main Remind pupils of the work they have done on oxidation reactions in the past. Remind them that, at its simplest level, oxidation is the reaction of something with oxygen. Review some of the word equations for oxidation reactions met in recent lessons, such as the reaction of carbon, iron or sulfur with oxygen. Establish that an oxide is always formed. General equation: element + oxygen → oxide Suggest to pupils that the same thing might happen to foods. This is a good opportunity to remind pupils that the air is about 21% oxygen. Ask pupils to carry out the ' Oxidation ' investigation described in the pupil book. You may wish to point out to pupils that the vinegars used are produced by leaving wine exposed to the air for a long period of time. There is an excellent opportunity to discuss the idea of a control in an experiment. [It is an idea which is often used in experiments where it is impossible to control all the variables and ensures that the scientist has something to compare their results to.] When reviewing the results of the experiment, establish that oxidation of food usually makes it acidic. You could ask pupils how they might find out if food <i>always</i> became acidic. Plenary - Living longer Advanced preparation needed. Show pupils a bottle of cooking oil which is about one-third filled with oil and has been left in a warm light place for about 2 weeks, with the lid sealed. Ask them to explain what might have happened and then lead on to ways in which foods can be protected from this. [The sides of the bottle will start to collapse as the oxygen in the air above the oil reacts and oxidises the oil. The oxides formed are not gases and so take up less space in the bottle, the pressure inside drops and the bottle sides collapse in. Fatty foods, such as crisps and nuts are often packed in bags filled with pure nitrogen instead of air. Nitrogen is very unreactive.] (5 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Ask pupils to think about ways we can keep food fresh at home, such as keeping things in the fridge or by keeping lids on jars and cereal packs closed up. Though some of these methods are about slowing the reproduction of microbes, they also restrict oxygen access and the rate of reaction with oxygen if it is present. • Extension. Ask pupils to consider redox reactions, as suggested in the 'Stretch yourself' section of the pupil book. Most metals are extracted by a redox reaction. For example, iron ore consists mostly of iron oxide. It is smelted with carbon to remove the oxygen from the iron (it is reduced) and the carbon gains the oxygen (it is oxidised). • Learning styles Visual: Observing the pH of substances. Auditory: Describing their observations. Kinaesthetic: Carrying out the investigation into oxidised foods and sorting foods into groups. Intrapersonal: Understanding that food oxidation can affect our health. • Homework. Pupils to find out if there are fresh foods at home which go brown when exposed to oxygen. Pupils could also test if lemon juice prevents it. [Apples, potatoes and avocado are examples.]
Learning Outcomes <i>All pupils should be able to state that oxidation is the reaction of a substance with oxygen.</i> <i>Most pupils should be able to write word equations for oxidation reactions.</i> <i>Some pupils should also be able to explain how oxidation and reduction can be considered as chemical opposites, giving examples.</i> How Science Works Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	Additional teachers notes Equipment and materials required - Per group: 1 cm ³ of a range of drinks and their vinegar counterparts, such as white wine, red wine, sherry, white wine vinegar, red wine vinegar, sherry vinegar, cider and cider vinegar. Universal indicator or a pH probe, spotting tile/dimple dish, dropping pipettes. Safety - Universal indicator is flammable: CLEAPSS Hazcard 32. Pupils must not taste any of the chemicals.	



Fusion 3: C2.6 – Acid and metal carbonate		
National Curriculum Link up •3.2b, 3.2c, 3.4c		
Learning Objectives Pupils should learn: What happens when an acid reacts with a metal carbonate. That all metal carbonates produce similar products when they react with acid.	Teaching / Learning activities Lesson structure Starter - One planet Give pupils statements about acid rain, global warming and the greenhouse effect. They must decide if the phrases are true or false. (5 mins) Main Remind pupils of the work they have done on acid reactions so far. It may also be a good time to remind them about oxidation reactions. Ask them to carry out the 'Metal carbonates and acids' investigation described in the pupil book. Ask pupils to make careful observations of what happens during the reactions. [The main observation is fizzing.] Establish that all the acid/carbonate combinations behave in the same way. Demonstrate to the pupils that the gas released is carbon dioxide. This could be carried out quite simply by the pupils themselves if you have the time available. Use the information gained to build up the general word equation for the reactions: acid + metal carbonate → a salt + water + carbon dioxide Remind them that the salt formed depends upon the metal part of the carbonate and the acid used. Pupils often think there is some sort of mystery surrounding chemical equations. Reassure them that there is not; if an element is not there at the start, it can't be there at the end. Begin to assemble some word equations for acid–metal carbonate reactions, using the pupil book to help. Pupils should be familiar with salts formed by the three main mineral acids; hydrochloric acid (forms chlorides), nitric acid (nitrates) and sulfuric acid (sulfates). Higher attaining pupils could consider other acids; ethanoic acid forms ethanoates, phosphoric acid would form a phosphate. Some pupils may need to spend some time identifying the name of the metal in the carbonate, though it is always written first. Plenary - Rules is rules Give pupils random acid–metal carbonate combinations, including ones not seen in the lesson and ask them to complete the word equations. (10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Preparing word equations from scratch is quite a high level skill. Concentrate instead on assembling word equations from limited list of 'parts'. Perhaps just consider one acid and vary the metal carbonate. • Extension. Ask pupils to prepare balanced symbol equations for the reactions they have seen in the lesson. • Learning styles Visual: Observing the effects of acid on metal carbonates. Kinaesthetic: Carrying out the practical work involving acids and metal carbonates. Intrapersonal: Understanding the 'rules' for acid–metal carbonate equations. • Homework. Pupils to find out why sherbet is fizzy. They could even buy and taste some sherbet as part of the work. [Sherbet contains a solid acid and a carbonate. When they get wet they react, producing carbon dioxide.]
Learning Outcomes <i>All pupils should be able to recall that acids react with metal carbonates to produce a salt, water and carbon dioxide.</i> <i>Most pupils should be able to complete word equations for the reactions, including predicting the salt formed.</i> <i>Some pupils should also be able to write balanced symbol equations for the reactions.</i> How Science Works. Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	Additional teachers notes Equipment and materials required Per group: Pieces of carbonate rocks, such as calcium carbonate (marble), magnesium carbonate and malachite (copper carbonate). 3 watch glasses, a few drops of 0.5 mol/dm ³ sulfuric acid, a few drops of 0.5 mol/dm ³ nitric acid, a few drops of 0.5 mol/ dm ³ carbonic acid, 3 dropping pipettes. Safety. Wear eye protection (chemical splash-proof). Sulfuric acid is an irritant: CLEAPSS Hazcard 98A. Nitric acid is corrosive: CLEAPSS Hazcard 67.	



Fusion 3: C2.7 – Making salts		
National Curriculum Link up •3.2b, 3.2c		
<p>Learning Objectives Pupils should learn: The difference between an acid and a base.</p> <p>What neutralisation is?</p> <p>How to make a salt.</p>	<p>Teaching / Learning activities Lesson structure Starter - pH mania Ask pupils to sketch out the pH scale and label it where they can. You could simplify the task by giving them an outline and a list of possible labels. (10 mins)</p> <p>Main Remind pupils of the work they have done on acids and making salts, particularly the work from last lesson on acid and metal carbonates. Remind pupils how changing the acid affects the salt formed. (Hydrochloric acid makes a chloride, nitric acid a nitrate, sulfuric acid a sulfate, etc.) Use the materials in the pupil book to support this.</p> <p>Ask pupils to plan, and if you have time, carry out the 'Investigating neutralisation' activity described in the pupil book. Encourage them to think of all the ways in which they know to make salts. Pupils will need to choose a suitable acid to use and then the right metal substance to react it with. They could use elemental metal, a base, alkali or carbonate. However, many elemental metals react very slowly with acid or dangerously fast. You could discuss the reactivity series at this point (see C1.4).</p> <p>There are myriad ways in which pupils could make the salts suggested so you will probably want to restrict their planning. The 'Practical Support' section contains a plan for two examples. Pupils may not recall how to obtain salt crystals from a solution of the salt and may require help with this. It should be done by evaporation over a water bath. [Evaporation is never carried out by heating the salt solution directly as the crystals, when they begin to form, may be decomposed by the heat of a Bunsen burner flame causing them to decompose. The decomposition products could be toxic.] Whichever reactants pupils choose to use, the basic process is the same: add a metal oxide or hydroxide to an acid until no more will react, filter out the excess oxide (if it's a solid) and then evaporate the salt solution to obtain salt crystals. You could ask pupils to make a particular salt, but provide a range of chemicals they could use and ask them to pick the correct combination.</p> <p>Plenary - What's in a name? Give pupils the names and formulae of some common acid, bases and salts. They must match the name to the correct formula. (5 mins)</p>	<p>Teaching suggestions</p> <ul style="list-style-type: none"> • Special needs. Pupils may well need help in planning the investigation. A suggested method that needs sorting into the correct order could be used. • Extension. Encourage pupils to think of all the possible ways to make the same salt, from a metal, a base or a carbonate. Ask them to explain why using a metal element is not a common choice. [Metals can react dangerously fast or too slowly.] • Learning styles Auditory: Planning the investigation. Kinaesthetic: Card sort for investigation method (SEN) and carrying out the investigation. Intrapersonal: Understanding that there are several ways to make a particular salt. • Homework. Pupils could find out which salts make good fertilisers and why. [Fertilisers are often used to supply extra nitrogen, phosphorus and potassium to plants. Potassium nitrate could, therefore, be used as a fertiliser.]
<p>Learning Outcomes <i>All pupils should be able to carry out a neutralisation reaction and to be able to make a sample of a salt.</i> <i>Most pupils should be able to explain that an acid is the chemical opposite of a base and that one can neutralise the other.</i> <i>Some pupils should also be able to explain, chemically, what happens during neutralisation and plan to make a salt safely.</i></p> <p>How Science Works Communicate effectively and use appropriate scientific terminology and conventions in discussion and written work. (1.1c) Explain how approaches to practical work were adapted to control risk. (1.2c)</p>	<p>Additional teachers notes Equipment and materials required. Neutralisation by alkali - Per group, to make sodium chloride: small beaker, 25 cm³ of 1 mol/dm³ hydrochloric acid + some spare in case of missing the point of neutralisation, 40 cm³ of 1 mol/dm³ sodium hydroxide, glass rod, 2 dropping pipettes, universal indicator, 1 spatula charcoal powder, filter funnel and paper, fl ask, evaporating dish, beaker for water bath, Bunsen burner, tripod and gauze, matches, chemical splash-proof eye protection. Neutralisation by base or carbonate - Per group, to make copper sulfate: small beaker, 25 cm³ of 2 mol/dm³ sulfuric acid, 10 g copper oxide powder, spatula, glass rod, filter funnel and paper, fl ask, evaporating dish, beaker for water bath, Bunsen burner, tripod and gauze, matches, chemical splash-proof eye protection.</p> <p>Safety. Wear chemical splash-proof eye protection. Sodium hydroxide is corrosive: CLEAPSS Hazcard 91. Universal indicator is flammable: CLEAPSS Hazcard 32. Copper oxide is harmful: CLEAPSS Hazcard 26. Sulfuric acid is corrosive: CLEAPSS Hazcard 98A. Copper sulfate: CLEAPSS Hazcard 27C. Do not allow the water bath to boil dry.</p>	



Fusion 3: C2.8 – Exothermic and endothermic reactions		
National Curriculum Link up •3.1a		
Learning Objectives Pupils should learn: What an exothermic change is. What an endothermic change is.	Teaching / Learning activities Lesson structure Starter - Energy, energy Show pupils a picture or video of a firework or bonfire. Ask them to list all the forms of energy they can see evidence of. [Energy is transferred out as sound, light, thermal and, for a firework, kinetic energy.] (5 mins) Main Explain that, during a chemical reaction, energy can be either transferred into or away from the reactants. If energy is transferred out, the change is said to be 'exothermic' (out-heat). If it is transferred in, the change is 'endothermic' (in-heat). Ask pupils to carry out the ' Classifying reactions ' investigation described in the pupil book. You may wish to discuss with them in advance the reasons for using polystyrene beakers rather than the usual glassware for the reactions. You could refer back to the experiments into energy release from fuels. [Expanded polystyrene is a thermal insulator.] Once pupils have collected their results, establish as a class which reactions resulted in an increase in temperature and which resulted in a decrease in temperature. You could invite pupils to guess whether an increase in temperature indicates an exothermic or an endothermic reaction. [This can be confusing. The thermometer does not measure the energy of the reacting chemicals. Instead it measures the temperature of the water that the chemicals are dissolved in. When the reaction gives out energy, it is transferred to the water. Thus in an exothermic reaction the temperature increases. The opposite is true for an endothermic reaction.] Establish which reactions are exothermic and which are endothermic. Explain to pupils that the vast majority of reactions are exothermic as the general trend is for substances to lose energy. An analogy might be something losing gravitational potential energy by rolling down a hill; objects never roll up a hill. Lead into the plenary by pointing out to pupils that although the words 'endothermic' and 'exothermic' are used, the energy transfer may not be in the form of heat. Plenary - Light fantastic Show pupils a 'glow stick' (a chemical-filled plastic tube which, when activated, transfers out light energy). Challenge pupils to explain how, even though little heat is generated, the glow stick is still a clear example of an exothermic reaction. (5 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Showing pupils a Bunsen burner flame could provide a more concrete experience of an exothermic reaction; they can feel the heat energy being transferred. • Extension. The idea of energy being transferred out causing the temperature of the reaction mixture to increase can initially sound contradictory. An explanation is included in the 'Main lesson' section, but you could ask pupils to explain it for themselves. Learning styles Auditory: Describing the results of the 'Classifying reactions' practical. Kinaesthetic: Carrying out the investigation into exothermic and endothermic reactions. Interpersonal: Discussing ideas with other pupils about whether a reaction is endothermic or exothermic. Intrapersonal: Understanding that all chemical changes involve energy transfer. <ul style="list-style-type: none"> • Homework. Pupils could find out what chemicals are in hand-warmers, self-heating coffee cups and first-aid cold packs.
Learning Outcomes <i>All pupils should be able to state that during an exothermic change the temperature measured increases and in an endothermic change it decreases.</i> <i>Most pupils should be able to explain that exothermic changes give out energy and endothermic changes take in energy, often as heat.</i> <i>Some pupils should also be able to explain why giving out energy makes the temperature increase.</i> How Science Works Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	Additional teachers notes Equipment and materials required. Per group: 3 polystyrene beakers (coffee cups), 3 thermometers, 3 x 10 cm ³ measuring cylinders, 25 cm ³ measuring cylinder, 2 spatulas, 10 cm ³ of 0.5 mol/dm ³ hydrochloric acid, 10 cm ³ of 0.5 mol/dm ³ sodium hydroxide, 10 cm ³ of 0.5 mol/dm ³ copper sulfate solution, access to water, spatula of magnesium powder, 3 spatulas of potassium nitrate, chemical splash-proof eye protection. Safety Wear chemical splash-proof eye protection. Check pupils do not use too much magnesium powder as the reaction may boil over. Sodium hydroxide is corrosive: CLEAPSS Hazcard 91. Hydrochloric acid: CLEAPSS Hazcard 47A. Copper sulfate: CLEAPSS Hazcard 27C. Magnesium powder is highly flammable: CLEAPSS Hazcard 59A. Potassium nitrate is oxidising: CLEAPSS Hazcard 82.	



Fusion 3: C2.9 – Conservation of mass		
National Curriculum Link up •3.2b		
Learning Objectives Pupils should learn: That mass is conserved during a chemical reaction. The difference between an open and a closed system.	Teaching / Learning activities Lesson structure Starter - What's the mass? Ask pupils what the mass of solution formed from 100 g of water and 10 g of sodium chloride would be. Demonstrate that it is 110 g, and ask them to explain why. (5 mins) Main Remind pupils of the differences between elements (substances made up of only one type of atom) and compounds (atoms of more than one element, chemically joined together). Challenge the class to suggest what happens to mass when a chemical reaction occurs. Ask pupils to carry out the ' Conservation of mass ' experiment described in the pupil book. Establish that mass is conserved. Explain to pupils that you are now going to show them some reactions where the mass <i>does</i> change, or at least appears to. Their challenge is to try to explain why. Get the class to carry out the ' Mass changes in a chemical reaction ' experiments described in the pupil book. Establish that, in the 'Conservation of mass' experiment the system was closed and the other experiments involved open systems. Explain that in an open system, atoms can enter and leave. The balance is recording the mass of atoms which have left or joined the system. To prove this we would need to capture the extra atoms and to record their mass. In the oxidation of magnesium, oxygen atoms from the air join with the magnesium, causing its mass to increase. Before the discovery of oxygen, scientists like Lavoisier and Priestly observed this happening but could not, initially explain it. The phlogiston theory was one early way to explain the phenomenon. Plenary - What happened? Ask pupils to write word, or even symbol, equations for all the reactions they have seen in the lesson. (10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Stick to the basic fact that mass does not change during a chemical reaction. You could use molecular models to demonstrate this. • Extension. Invite pupils to devise a way to prove that mass is conserved during the 'Mass changes in a chemical reaction' experiments. • Learning styles Visual: Observing the chemical reactions to confirm that they have taken place. Kinaesthetic: Carrying out mass conservation reactions. Interpersonal: Working with others during the practicals. Intrapersonal: Understanding that initial evidence may require closer inspection, such as in mass changes in an open system.
Learning Outcomes <i>All pupils should be able to state that mass is conserved during a chemical reaction.</i> <i>Most pupils should be able to explain that, if a system is open and a gas given off, that mass may appear to decrease.</i> <i>Some pupils should also be able to explain how, in an open system oxidation reaction, mass appears to increase.</i> How Science Works Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	Additional teachers notes Equipment and materials required. Starter - Demonstration apparatus: 250 cm ³ beaker, 1 decimal place balance, 100 g of water, 10 g of sodium chloride, glass rod, weighing bottle. Conservation of mass - Apparatus per group: 20 cm ³ of 0.1 mol/dm ³ magnesium sulfate solution, 20 cm ³ of 0.1 mol/dm ³ barium chloride solution, 100 cm ³ beaker, 1 decimal place balance (2 decimal place balance may show a mass change), 2 measuring cylinders. Mass changes - Apparatus per group: small beaker, 25 cm ³ of 1 mol/dm ³ hydrochloric acid, 2 spatulas of small marble chips, 5–10 cm piece of magnesium ribbon, nickel crucible and lid, tongs, pipe-clay triangle, Bunsen burner, tripod and heat-proof mat, matches, electronic balance (2 decimal places is good). Safety. Barium chloride is harmful: CLEAPSS Hazcard 10A. Eye protection must be worn. Pupils must not look into crucible while lifting the lid in case the magnesium ignites; it burns with a very bright flame. Be careful with hot equipment.	