Fusion 3: C1.1 – Marvellous Metals

National Curriculum Link up
•1.1b, 1.2b, 3.2a, b and c, 3.4c

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: The difference between metals and non-metals. The properties of metals.	**Lesson structure** **Starter – Metal magic** Ask pupils to list the names of as many metals as they can think of. The longest list wins. (10 mins) **Main** Remind pupils that they have met metals before and explain that the purpose of this lesson is for them to re-familiarise themselves with the differences between metals and non metals. You could start by getting the class to contribute to a 'brain-storm' of what they know about metals. Ask pupils to undertake the **'Investigating properties of metals'** activity described in the pupil book. This recaps on the activity in Fusion Book 1. After the activity, ask pupils to work in small groups to write a definitive list of the properties of metals and non-metals. Explain to pupils that of the approximately 100 elements, there are around 75 metals which occupy all but the upper-right-hand end of the Periodic Table. **Plenary - Is it a metal?** Demonstrate, using a simple circuit, that a piece of graphite will conduct electricity. Ask pupils whether it is a metal or a non-metal. [Graphite is an allotrope of carbon whose bonding leaves some free electrons. These electrons can move through the material allowing it to conduct electricity. Carbon is really a non-metal – it is dull in appearance and brittle. Other allotropes of carbon include diamond and fullerenes] (10 mins)	• **Special needs.** Pupils may well need help setting up the series circuit. • **Extension.** Ask pupils to research what a metalloid is, paying particular attention to silicon. [A metalloid is an element which exhibits some of the properties of metals and some of those of non-metals. They are found in the Periodic Table at the border between metals and nonmetals. Silicon conducts electricity, making it metal like. However, it is also brittle, making it like non-metals. Two forms of silicon are used together to make transistors – electronic switches. There are millions of tiny transistors inside a computer processor.] • **Learning styles.** *Visual:* Making observations during the investigation. *Auditory:* Discussing, in groups, the definitive list of metal properties. *Kinaesthetic:* Carrying out practical work. *Interpersonal:* Sharing ideas with other pupils.

Learning Outcomes
All pupils should be able to identify a metal and a non-metal.
Most pupils should be able to state the key properties of metals and non-metals.
Some pupils should also be able to explain what a metalloid is.

Additional teachers notes
Investigating the properties of metals - Equipment and materials required
Per group: strips or pieces of a range of metals, such as iron nail, zinc foil, aluminium foil, copper foil, nickel foil, magnesium ribbon; hand lens or magnifying glass, small bowl of water, wooden board or heat-proof mat and a small hammer, series circuit containing a power supply or cell, a lamp a switch, wires and two crocodile clips to insert the metal sample between.
Safety. Do not use large pieces of metals which could injure feet if dropped. Crocodile clips can get hot if the circuit is left on for a long period of time. Care with the hammer.
Plenary: Is it a metal? - Equipment and materials required
Demonstration apparatus: circuit as per pupil investigation, piece of graphite.
Safety
Crocodile clips can get hot if the circuit is left on for a long period of time.

Fusion 3: C1.2 – Metals and oxygen

National Curriculum Link up
•2.1a, 3.2b

Learning Objectives
Pupils should learn:
What happens when a metal reacts with oxygen.

Whether all metals react with oxygen.

Teaching / Learning activities
Lesson structure
Starter - Where's the shine?
Show pupils a picture of a piece of rusty metal and some tarnished silver. Ask them to suggest what might have happened. Give them time in groups to discuss their ideas. [The metals react with oxygen in the air.] (10 mins)
Main
Remind pupils of the range of metal elements which are listed on the Periodic Table. It might be a good opportunity here to do a quick verbal test on the typical properties of metals. Remind pupils about the amount of oxygen in our atmosphere [21%] and explain that this oxygen can react with metals which are exposed to it. Ask pupils if they can remember what some of the signs of a chemical reaction are [e.g. colour change, fizzing, heat given off] and then invite them to carry out the '**Investigating the reaction of metals and oxygen'** activity described in the pupil book.
Establish that the metals have reacted with oxygen in the air; they have been oxidised and the magnesium is much more reactive than the iron.
Remind pupils that we can describe the progress of a chemical reaction using a word equation. Ask pupils to write word equations for the reactions they have seen, based on the general equation: metal + oxygen metal oxide.
Plenary - What's the pattern?
Extend the word equation writing from the main lesson to include metals not seen in the lesson. This is an ideal opportunity to teach pupils about the idea that chemical reactions follow patterns. (10 mins)

Teaching suggestions
• **Special needs.** Give pupils cards with the names of products and reactants on to help them build up the work equations.
• **Extension.** Ask pupils to write balanced symbol equations for the reactions after they have completed the word equations.
• **Learning styles**
Visual: Observing chemical reactions.
Auditory: Describing their observations.
Kinaesthetic: Reacting the metal with oxygen.
Intrapersonal: Understanding the concept of word and symbol equations.
• **Homework.** Gold will only react with oxygen plasma. Ask pupils to find out what plasma is [very high energy gas].

Learning Outcomes
All pupils should be able to state that when a metal reacts with oxygen a metal oxide is formed.
Most pupils should be able to write word equations for the reactions and observe differences in reactivity.
Some pupils should also be able to write balanced symbol equations for the reactions.
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 Apparatus per group: 2 gas jars of oxygen (plus some
spares available in case the reaction doesn't work first time), two 3 cm long strips of magnesium ribbon, 2 marble sized balls of iron wool (must not be tightly squashed or it won't ignite), 2 deflagrating spoons, tongs, Bunsen Burner, heat mat, matches, blue cobalt glass, eye protection. Optional: piece of copper foil.
Safety Eye protection must be worn. Pupils must observe the burning magnesium through blue glass. Magnesium ribbon: CLEAPSS Hazcard 59A. Oxygen: CLEAPSS Hazcard 69.

Fusion 3: C1.3 – Metals and water

National Curriculum Link up
•1.1b, 3.2b, 3.2c

Learning Objectives **Pupils should learn**: What happens when a metal reacts with water? That there are differences in the ways different metals react with water.	**Teaching / Learning activities** **Lesson structure** **Starter - It's a gas?** Ask pupils to correctly match up statements which give the name of a gas (hydrogen, oxygen and carbon dioxide), the test for that gas and the positive outcome of the test. (5 mins) **Main** Remind pupils of the work they have done about metals so far, especially about their properties. Remind them of the idea they met last lesson that some metals are more reactive than others. Suggest to them that some metals are so reactive that they will react with cold water. Then demonstrate the reaction of the first three elements in Group 1 of the Periodic Table; lithium, sodium and potassium. Once you have shown these to the pupils, you may wish to show them videos of the next two elements in the group reacting with water; rubidium and caesium. [If you have time, this is an ideal opportunity to introduce the concept of groups to pupils.] Before showing pupils videos of rubidium and caesium ask them to predict what they think will happen based on the reactivity of the first three elements in the group.] Get pupils to carry out the **'Reactions of metals with water'** investigation described in the pupil book. Based on the evidence seen in the two experiments, establish that hydrogen gas is given off, and build up word equations of the general form: metal + water → metal hydroxide + hydrogen. Ask pupils to write the metals in a 'league table'. in order of reactivity. They will meet the reactivity series formally in a later lesson, but this is an opportunity to start to build up the idea of one. Place metals in order from most to least reactive. Potassium (or caesium if shown) should be at the top. **Plenary - Spot the pattern** Invite pupils to write word equations for the reaction with water of metals not shown to them in the lesson. (5 mins)	**Teaching suggestions** • **Special needs.** Concentrate on making observations of the reactions and using this information to establish the order of reactivity of the metals. • **Extension.** Ask pupils to convert the word equations into balanced symbol equations. • **Learning styles** **Visual:** Observing the reactions between metals and water. **Auditory:** Describing their observations. **Kinaesthetic:** Reacting metals with acids. **Intrapersonal:** Understanding that some metals are more reactive than others and that there are patterns in reactivity. • **Homework.** If you haven't shown them video clips in the lesson, ask pupils to find out about the reactions of rubidium and caesium with water.

Learning Outcomes *All pupils should be able to* explain that, when a metal reacts with water, hydrogen gas is released. *Most pupils should be able to* write word equations for the reactions and observe differences in the reactivity. *Some pupils should also be able to* write balanced symbol equations for the reactions. **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. Demo Group 1 metals + water -** rice grain sized piece of lithium metal, rice grain sized piece of sodium metal, rice grain sized piece of potassium metal, filter paper, large glass bowl, one-third filled with water, safety screens, tweezers, universal indicator solution, eye protection (or full face shield), Optional: visualiser, scalpel for cutting metals, white tile to cut on, matches and splints, filter paper (to absorb oil). **Safety -** Do not react large pieces. Hold the metal with tweezers rather than tongs. Ensure pupils are viewing the reaction through, rather than round, the safety screen. A glass or Perspex sheet over the top of the safety screens stops hot metal spitting over the top. Keep pupils well away. Lithium metal is highly flammable and corrosive: CLEAPSS Hazcard 58. Sodium metal is highly flammable and corrosive: CLEAPSS Hazcard 88. Potassium metal is highly flammable and corrosive: CLEAPSS Hazcard 76. **Metals + water -** Apparatus per group: 2–3 small pieces of calcium, 1–2 cm strip of magnesium ribbon, a small piece of copper foil, 3 small beakers or boiling tubes, 3 test tubes, measuring cylinder (5 cm3), tweezers, matches and a splint, spatula, emery cloth, eye protection. **Safety** - Do not react large pieces of calcium. Hold calcium with tweezers. Wear eye protection. Magnesium ribbon: CLEAPSS Hazcard 59A. Calcium metal is highly flammable: CLEAPSS Hazcard 16.

Fusion 3: C1.4 – Metals and acid

National Curriculum Link up
•1.1b, 3.2b, 3.2c

Learning Objectives
Pupils should learn:
What happens when a metal
reacts with an acid.

That not all metals react with acids.

Teaching / Learning activities
Lesson structure
Starter - pHancy that!
Read out statements about the pH scale. Pupils must decide if they are true or false. (5 mins)
Main
Remind pupils of the work they have done on pH in the last few lessons. Also remind them of the differences in reactivity seen last lesson. Explain that in this lesson they are going to be reacting metals with acids.
Ask the pupils to carry out **'Reacting metals with acids'** as described in the pupil book. While doing the experiment ask pupils to consider which metal is the most reactive.
Give pupils the general equation for the reaction:
metal + acid → metal salt + hydrogen gas
Build up, with pupils help, the word equation for the magnesium reaction:
magnesium + hydrochloric acid → magnesium chloride + hydrogen
Establish that there is no 'trickery' in chemical reactions; whatever is there at the start is there at the end and if it isn't there at the start, it can't be there at the end. In these reactions, the hydrogen in the acid 'swaps places' with the metal. The name of the salt will always be: name of metal, followed by the salt-type formed from the acid. When hydrochloric acid is used a chloride is made, when nitric acid is used a nitrate is made and when sulfuric acid is used a sulfate is made.
Ask pupils to predict the salt made when a given metal and acid react and perhaps to write the word equations.
Plenary - Safety matters
Ask pupils to suggest why many of the metals seen last lesson, such as potassium, should not be added to acid. [The reaction is much more violent than with water.] (5 mins)

Teaching suggestions
• **Special needs.** Writing word equations is a relatively high level skill. It can be simplified by using molecular model sets to represent parts of molecules. The colours used are not really relevant but an acid should be made of two different coloured parts: one for the hydrogen and one for the rest. Pupils can then model the metal replacing the hydrogen.
• **Extension.** Ask pupils to write balanced symbol equations for the reactions they have seen in the lesson.
• **Learning styles**
Visual: Observing the reactions between metals and acid.
Auditory: Writing word equations.
Kinaesthetic: Reacting the acids with the metals.
Intrapersonal: Understanding that, in a reaction, nothing is created or destroyed.
• **Homework.** Ask pupils to find out what table salt, sodium chloride, is used to make. [There are many substances which rely on sodium chloride as the raw material, e.g. we obtain hydrogen for use as a fuel, chlorine for making PVC and bleach, sodium hydroxide for making soaps and cleaners.]

Learning Outcomes
All pupils should be able to state that when a metal reacts with an acid, a metal salt and hydrogen gas are formed.
Most pupils should be able to write word equations and describe differences in reactivity.
Some pupils should also be able to write balanced symbol equations and to predict the products of unseen reactions.
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: 9 cm^3 of 0.4 mol/dm^3 hydrochloric acid, 1 small piece each of magnesium ribbon, zinc foil, copper (or silver) foil, small piece of sandpaper to remove dirt/corrosion from metal, 3 test tubes, test tube rack, eye protection.
Safety
Eye protection must be worn.
Hydrochloric acid: CLEAPSS Hazcard 47A.
Magnesium ribbon: CLEAPSS Hazcard 59A.

Fusion 3: C1.5 – Reactivity Series

National Curriculum Link up
•1.1b, 3.2b, 3.2c

Learning Objectives
Pupils should learn:
That some metals are more reactive than others.

What the reactivity series is.

Teaching / Learning activities
Lesson structure
Starter - What a state
At this stage in Key Stage 3 science, it is worth trying to get the pupils to recall previous work. Show pupils diagrams of the particles in solids, liquids and gases and ask them to say which is which and to justify their answers. (5 mins)
Main
Remind pupils of the experiments they have carried out over recent lessons. Discuss the fact that they have looked at metals reacting with different substances and that some reacted more readily than others.
Introduce the idea of a reactivity 'league table', with very reactive metals at the top and less reactive ones near the bottom.
Ask pupils to carry out the activity in the pupil book; **'The reactivity series'**. This activity may work better if pupils have not seen the text book first, so they can't 'cheat' by looking at the reactivity series printed there. A good way for pupils to do this activity is to ask them to write the name of each metal they have met in this topic on a square of paper. Alongside the name they could note down any reactions they have seen it undergo. They can then sort the metals into order according to their reactivity, with the most reactive at the top. Once they have completed their series they could compare it with other pupils before checking against the one in the book.
Explain to pupils that the reactivity series is very important as it can be used to predict whether reactions are possible or not. They will be looking at this in future lessons. You may also like to say that, if we wanted to, we could include every element in the reactivity series. Mostly, however, we only include about 15 metals and, perhaps carbon and hydrogen.
Plenary - That can't be right?
By dipping a piece in some acid, show pupils that aluminium is difficult to place in the reactivity series as it appears unreactive. Sand the surface and then dip it in again. [Aluminium reacts quickly with oxygen to form a tough layer of oxide on the surface which prevents it from reacting. Sand the coating off and it will react. Aluminium is self protecting in this respect. Rust forms a loose layer on the surface of iron which does not prevent metal underneath from corroding.] (10 mins)

Teaching suggestions
• **Special needs.** Give students pre-prepared cards, with some basic reaction data about metals they have seen in previous lessons, to sort during the main pupil activity.
• **Extension.** Challenge pupils to explain why ships often have a large block of a reactive metal such as magnesium bolted to them. [The magnesium is much more reactive than the iron in the steel hull of most ships. The magnesium reacts with the seawater and oxidises instead of the hull. The hull stays undamaged by corrosion for much longer. The magnesium block will dissolve but is easily replaced.]
• **Learning styles**
Auditory: Justifying their reactivity series.
Kinaesthetic: Sorting their reactivity series.
• **Homework.** Ask pupils to find out where other metals should fit into the reactivity series.

Learning Outcomes
All pupils should be able to describe how some metals are more reactive than others.
Most pupils should be able to explain the sequence of the metals in the reactivity series.
Some pupils should also be able to explain how sacrificial protection works.

Additional teachers notes
Equipment and materials required Plenary: That can't be right?
Demonstration apparatus: 1 piece of aluminium, not fresh and shiny, small beaker, containing 50 cm3 of 1 mol/dm^3 hydrochloric acid, sand paper, paper towels (to wipe dry the aluminium), eye protection.
Safety Wear eye protection.
Rinse hands immediately if you get acid on them; hydrochloric acid: CLEAPSS Hazcard 47A.

Fusion 3: C1.6 – Solid displacement

National Curriculum Link up
•3.2b, 3.2c

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: What displacement is? When a metal will displace another from a compound.	**Lesson structure** **Starter - Missing words** Show pupils a reactivity series with some of the elements missing from it. Ask them to add the missing ones. To support lower attainers, you could give them elements from which to select the missing ones. (5 mins) **Main** Remind pupils of the work they have done on the reactivity series and explain that we can use the reactivity series to predict whether a reaction will happen or not. Explain the idea of displacement: that one metal can push another out of a compound if it is reactive enough. It can be helpful to conjure up the image of a tug of war, with the two metals pulling on the rope from either end. The most reactive metal will win. Be aware that with this analogy some pupils like to suggest that one metal is 'stronger' than the other, which is not the case: formal explanations should use the term 'more reactive'. Demonstrate the thermite reaction to pupils, with great care. Explain that aluminium is more reactive than iron so it can take the oxygen away from it. Ask pupils to predict whether there would be a reaction between zinc and potassium oxide [there wouldn't, zinc is lower in the reactivity series than potassium] and magnesium and copper oxide [there will – magnesium is much higher than copper]. Demonstrate that magnesium will react with copper oxide. **Plenary - Will it, won't it?** Suggest some other possible displacement reactions to pupils and ask for their predictions. (5 mins)	• **Special needs.** Predicting whether a reaction will happen using the reactivity series is quite conceptual. It can be made easier by giving pupils the word 'oxide' on a piece of card. They can place the card next to the element which has the oxygen on the periodic table and then see much more easily whether the element which is trying to 'steal' it is able to. **Extension.** Ask pupils to consider why a vigorous reaction is not seen when a metal at the top of the reactivity series tries to displace one below it, but also near the top of the series. • **Learning styles** **Visual:** Observing the displacement reactions. **Intrapersonal:** Using the reactivity series to decide whether a reaction will happen or not. • **Homework.** Pupils could find out what the thermite reaction is used for, apart from joining railway lines. [It has been used in many situations where using traditional welding machinery would be problematic. It has been used to weld metal underwater.]

Learning Outcomes	Additional teachers notes
All pupils should be able to state that a more reactive metal will displace a less reactive one. *Most pupils should be able to* write word equations to describe displacement reactions. *Some pupils should also be able to* use the reactivity series to predict whether or not a displacement reaction will take place.	**Equipment and materials required - Demonstration thermite apparatus:** 9 g iron oxide powder, 3 g aluminium powder, 0.2 g magnesium powder and 2 g barium nitrate powder, mixed carefully to make the igniter, 10 cm magnesium ribbon, eye protection, safety screens. See pupil book for apparatus. **Safety** Wear eye protection and a lab coat. Pupils must also wear eye protection. Use safety screens. If carried out correctly, this reaction is exciting but safe. CLEAPSS guide L195 provides the latest advice for setting up this reaction. Aluminium powder is highly fl ammable: CLEAPSS Hazcard 01. Magnesium powder is highly flammable: CLEAPSS Hazcard 59A. Barium nitrate is oxidising and harmful: CLEAPSS Hazcard 11. **Reaction between copper oxide and Magnesium - Equipment and materials required** Demonstration apparatus: 0.5 g copper oxide, 0.5 g magnesium powder, 2 bottle tops (with plastic liner removed by burning), Bunsen burner and tripod, pipeclay triangle, matches, eye protection, safety screens. **Safety** - Wear eye protection or a face shield. Use safety screens. The room should be well-ventilated to remove the smoke. Protect the bench with hardboard or heat-proof mats. Pupils should stand towards the back of the room. Magnesium powder is highly flammable: CLEAPSS Hazcard 59A. Copper oxide is harmful: CLEAPSS Hazcard 26.

Fusion 3: C1.7 – Solution displacement

National Curriculum Link up
•3.2b, 3.2c

Learning Objectives
Pupils should learn:
Whether or not a metal can displace another metal from its solution.

Whether or not the reactivity series can be used to predict the outcome of a reaction.

Teaching / Learning activities
Lesson structure
Starter - (Dis)Solve it!
Ask pupils to match up solution key words, such as solvent, solute, solution, dissolve, soluble, insoluble, with their definition. (10 mins)
Main
Remind pupils about the work they completed last lesson on solid displacement and using the reactivity to predict the outcome of displacement reactions.
Explain that in this lesson they are going to see if the same principles can be applied when one of the metals is solid and one is in solution.
Ask pupils to carry out the 'Solution displacement' investigation described in the pupil book. They will need to follow the instructions carefully and, perhaps, to label the spotting tile to avoid confusion. A good way to record the results is to prepare a grid with the names of the metals down the side and the sulfates across the top. The pupils can then record whether a reaction happened or not in the grid with a simple tick or cross; half the reactions should work while the others will not.
Once they have completed the experiment, ask pupils to list the metals in order of reactivity, according to their results. The principle is similar to that of solid displacement (last lesson); a more reactive metal will go into solution, forcing the less reactive one out of solution where it will appear as a solid.
Ask pupils to prepare word equations for the reactions which do work.
Plenary – Modelling displacement
Ask students why the cartoon model of a displacement reaction on page 66 can be useful. What are its strengths and weaknesses as a model for displacement in solution? (5 – 10 mins)

Teaching suggestions
• **Special needs.** There is ample room for confusion and opportunity to get solutions mixed up with the pupil investigation into solution displacement. It may be helpful to do the experiment in stages.
• **Extension.** Before undertaking the pupil activity, ask pupils to predict the outcome of all the reactions and hand in their predictions. After completing the experiment, they can check whether they were correct or not.
• **Learning styles**
Visual: Observing whether a displacement reaction has occurred or not.
Kinaesthetic: Carrying out the displacement reactions.
Intrapersonal: Using the reactivity series to decide whether reactions will happen or not.
• **Homework.** Complete some word (or symbol) equations for displacement reactions of some metal nitrate solutions.

Learning Outcomes
All pupils should be able to state that a more reactive metal will displace a less reactive one from its solution.
Most pupils should be able to write word equations for displacement reactions.
Some pupils should also be able to predict the outcome of a displacement reaction using the reactivity series.
How Science Works
Explain why the manipulation of a model or analogy might be needed to clarify an explanation. (1.1a1)

Additional teachers notes
Equipment and materials required
12 cell spotting tile (dimple dish), 3 cm3 of 0.5 mol/dm3 magnesium sulfate, 3 cm3 of 0.5 mol/dm3 copper sulfate, 3 cm3 of 0.5 mol/dm3 zinc sulfate, 3 cm3 of 0.5 mol/dm3 iron(II) sulfate; three small pieces each of copper foil, magnesium ribbon, zinc foil; 3 pinches of iron filings, eye protection.
Safety
Wear eye protection.
Zinc sulphate is an irritant: CLEAPSS Hazcard 108B.

Fusion 3: C1.8 – Extraction of metals

National Curriculum Link up
•3.2b

Learning Objectives
Pupils should learn:
In what form metals are found in the Earth's crust.

How metals can be extracted for our use.

Teaching / Learning activities
Lesson structure
Starter - Gold rush
Show pupils a video or a photo of people panning for gold. Challenge them to explain why no-one bothers to pan for sodium. (5 mins)
Main
Remind pupils of the work they have done on the reactivity series and displacement reactions. Explain that many metals are obtained by displacement reactions.
Ask them to guess (if you haven't already shown them the pupil book) which metals they think might be found as pure metals. [The metals at the bottom of the reactivity series often have not reacted with anything, since they
were formed early in the Earth's existence: platinum, gold and silver. Copper too can sometimes be found 'native', though it often has to be extracted from minerals.]
Introduce the idea that most metals have reacted with something, usually oxygen, since they came into existence on Earth, and that means we have to displace the metal from the compound in which it is found. Compounds we can dig up which are rich in metals are called 'ores'.
Ask pupils to carry out the **'Smelting'** activity described in the pupil book. Explain that this will only work for metals which are less reactive than carbon; the carbon displaces metals like lead and iron from their oxides. The method they have used is applied on an industrial scale to several metals, including lead and iron.
Explain that any metal more reactive than carbon must be extracted by electrolysis. This applies to all metals from aluminium upwards.
Plenary - Extraction conundrum
Read out names of metals from the periodic table, randomly. The pupils must try to remember where the metals are in the reactivity series and to then say how they are likely to be extracted: native, smelting or electrolysis. An electronic resource is available for this. (5 mins)

Teaching suggestions
• **Special needs.** Electrolysis is a very hard concept to grasp and may be best avoided with lower attaining pupils. Concentrate instead on dividing up the reactivity series. Pupils do not need to be able to explain electrolysis, only that metals from aluminium upwards cannot be extracted by carbon.
• **Extension.** There is a 'Stretch yourself' section in the pupil book about the use of electrolysis to extract highly reactive metals such as aluminium. Electrolysis is very expensive as it uses so much electrical energy. Ask pupils to find out how aluminium is electrolysed industrially.
• **Learning styles**
Visual: Observing the formation of lead by smelting.
Kinaesthetic: Smelting lead.
Interpersonal: Working with others during the practical.
Intrapersonal: Understanding that rocks contain many metal compounds from which we can extract our metal.
• **Homework.** Pupils could find out about the Iron Age: when it happened and how it changed life for people.

Learning Outcomes
All pupils should be able to state that all metals are found in and extracted from the Earth's crust.
Most pupils should be able to recognise that unreactive metals are found native and explain why carbon can be used to extract iron.
Some pupils should also be able to explain why electrolysis must be used to extract aluminium.

Additional teachers notes
Equipment and materials required
Per group: 1 spatula of powdered charcoal, 1 spatula of lead oxide, boiling tube, small piece of mineral wool to plug Pyrex boiling tube, test tube holder, heat-proof mat, Bunsen burner, matches, eye protection.
Safety
Wear eye protection.
Take extra care if pregnant.
Ensure boiling tube is not pointing at anyone. Care must be taken when tipping out the boiling tubes to ensure that molten lead and red hot charcoal do not spill. Lead oxide is toxic: CLEAPSS Hazcard 56.

Fusion 3: C1.9 – What's the damage?

National Curriculum Link up
•1.2b, 3.4b

Learning Objectives
Pupils should learn:
To consider whether metal extraction is ethical.

To consider whether we should continue to refine metals.

Teaching / Learning activities
Lesson structure
Starter - World without metal
Make a list of all the items in the room which would disappear if we had no metal. Longest list wins. (5 mins)
Main
Remind pupils about the work they did on metal extraction last lesson. Recap the general process; metal
ore and fuel must be extracted from the ground, ore is smelted or electrolysed, crude metal processed to improve its properties using more energy, and finally products can be made from it and distributed.
Give the class some stimulus material to help them think about the issues involved in these processes by showing them photographs and videos of the main stages in metal production. You could, at this point, divide the class into groups and get them to think about the issues of one aspect, with one pupil leading each group. Give pupils time to consider some of the ideas and the advantages and disadvantages.
Once the pupils have had a chance to consider the issues hold a class debate. You, or an appointed pupil, could chair it, or you could hold the debate in the form of an open meeting; pupils representing different viewpoints must sit at the front of the room. They should have the chance to make a brief speech and then they must answer questions.
Once the debate has been allowed to run for some time, you could ask pupils to vote on whether we should continue to extract new metal. You could, at this point, introduce the idea of recycling metal rather than producing fresh metal and ask pupils whether they think this is viable for every metal item.
Plenary - What do you know?
Ask pupils to write an answer to the aims in the pupil book at the start of the spread. (5 mins)

Teaching suggestions
• **Special needs.** Instead of holding a debate, you could ask pupils to research the impact of a mine on the internet. You could also ask more closed questions to convey the key points. For example, you could ask pupils to list all the people who might like a mine to open in the local area or ask them why an unemployed person might be keen on it.
• **Extension.** This is an ideal opportunity for higher attaining pupils to lead the class discussion. You could give these pupils particular roles to adopt, such as the owner of the mining company, the local resident, the leader of the local council, the manager of the local job centre, an unemployed local or a local wildlife enthusiast. Pupils would then have to make a case in that role and prepare
a speech for the class discussion.
• **Learning styles**
Visual: Observing pictures of metal extraction processes.
Auditory: Taking part in the class debate, while speaking and listening to others.
Interpersonal: Understanding the viewpoints of others.
Intrapersonal: Considering their own standpoint on the extraction of metals.
• **Homework.** Pupils to find out about the impact a real mine, preferably one local to the school, has had on the environment and the changes it has caused.

Learning Outcomes
All pupils should be able to explain why metals are important to our lives but that extraction damages the environment.
Most pupils should be able to explain how mining and energy use affect our environment.
Some pupils should also be able to prepare their own case for or against a mineral mine.
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
Safety

Fusion 3: C1.10 – Metal corrosion

National Curriculum Link up
•2.1a, 3.2b

Learning Objectives	Teaching / Learning activities	Teaching suggestions
Pupils should learn: What metal corrosion is? What rusting is and what causes it. How to evaluate an investigation.	**Lesson structure** **Starter - Going, going, gone** Show pupils a picture of a really rusty piece of metal. Ask them to explain what is happening. (5 mins) **Main** Remind pupils of the work they have done on the reactivity series, especially about the Group 1 metals which have to be kept in oil to prevent them from reacting with oxygen in the air. Refer also to the extraction of metals; we have to extract metals from their ores as, over time, they react with other substances. Introduce the idea that metal objects won't last forever and hold a short class debate about why. You may need to correct a common misconception here, as pupils often talk about metals rusting. Rust is the common name for the compound iron oxide, hence only iron can rust. Rusting is a form of corrosion which most metals are susceptible to. Ask pupils to set up the **'Rusting experiment'** described in the pupil book. This is a very good opportunity to talk about the variables in an experiment and how we can make the test fair (How Science Works). In this case, the nails should all be the same and the tubes should be left in the same place to ensure that air circulation and temperature are as similar as possible (apart from the sealed tubes). The length of time the tubes are left for should also be the same. You may also wish to ask the pupils to set up a control; an iron nail in a dry test tube. [The control can be used as a comparison at the end of the experiment.] Especially if you plan to leave the tubes and return to them in a few days, you could ask the pupils to predict what they think will happen. You may need to discuss with pupils what is present/absent from each tube; oxygen, water or salt, so that they don't get distracted by the chemicals added. Give pupils the word equation for rusting: iron + oxygen → iron oxide, to help them make their predictions. **Plenary - Slow lane** Ask pupils to consider why cars in hot countries, such as Saudi Arabia, tend to last longer than in colder, damp ones, like the UK. [The dry air in hot countries does not have enough moisture in it for rusting to happen quickly.] (5 mins)	**• Special needs.** Most of this lesson is very accessible to all pupils. You may wish to miss out the discussion about fair testing for some pupils. **• Extension.** If you didn't use the 'That can't be right' plenary in C1.5, you could ask pupils to research why aluminium does not corrode quickly. **• Learning styles** **Auditory:** Describing observations of the rusting experiment. **Visual:** Observing the results of the rusting experiment. **Intrapersonal:** Understanding that rusting is the opposite chemical process to smelting. **• Homework.** Pupils could look for rusty items at home and suggest how the rusting could be slowed or prevented.

Learning Outcomes
All pupils should be able to state that metals corrode, iron rusts and that this weakens the metal.
Most pupils should be able to describe how iron rusts most rapidly when oxygen, water and salt are present.
Some pupils should also be able to balance a symbol equation by themselves.
How Science Works
Explain how improvements to the planning and implementation would have led to the collection of more valid and reliable evidence and a more secure conclusion. (1.2e)

Additional teachers notes
Equipment and materials required
Per group: 4 or 5 test tubes (depending on whether you wish pupils to set up a control), 4 or 5 iron nails (37–50 mm in length), 10 cm^3 boiled water, 3 cm^3 tap water, 10 cm^3 salt water (10% solution), 1 cm3 paraffin or cooking oil, 1 spatula of anhydrous calcium chloride, spatula, bung for test tube, test tube rack.
Safety
Calcium chloride is an irritant: CLEAPSS Hazcard 19A.

Fusion 3: C1.11 – What's the use?

National Curriculum Link up
•3.2a, 3.2b

Learning Objectives
Pupils should learn:
Why certain metals are chosen for particular purposes.

How we can change the properties of a metal by making an alloy.

Teaching / Learning activities
Lesson structure
Starter - Particles
Ask pupils to sketch the arrangement of the particles in solids, liquids and gases. [Solids: all particles touching, neatly arranged. Liquids: most particles touching, not neatly arranged. Gases: particles not touching and randomly arranged.] (10 mins)
Main
Ask pupils to list the key properties of metals. [Shiny, conduct heat and electricity, malleable, ductile, sonorous, strong, high melting and boiling points]. Explain that, while these properties are typical, they do vary from metal to metal.
Ask pupils to recall the uses of some of the metals and then to work in small groups to come up with a list of properties of that metal which make it suitable for that use, e.g. copper is used to make electrical wires as it is a very good conductor of electricity and fl exible so the wires will bend.
Introduce the idea that sometimes we would like to change and improve the properties of a metal. By mixing metals together, we can make an alloy which may have better properties for a particular use than the original metal. For example, solder has a low melting point.
Ask pupils to carry out the **'Alloys'** investigation described in the pupil book. You may wish to discuss the idea that pupils will be using bubbles to model the behaviour of atoms in metals.
Regroup to assess the pupils' findings. The presence of a small quantity of atoms of another metal (the large bubbles) disrupts the arrangement of the particles. It may be a good time to review the arrangement of particles in a solid. The metal atoms are not able to slide around so easily which generally makes alloys harder than pure metals. Alloy wheels on a car are mostly aluminium. If they were pure aluminium they would be too soft and would buckle easily.
You could introduce pupils to the idea that steel, while mostly iron, has other metals (and often carbon) added to alter its properties. [Adding chromium makes steel more rust-proof, adding manganese makes it more springy as in paperclips.]
Plenary - Designer metal
Ask pupils to design the properties an alloy must have to be suitable for a particular use, for example, a space rocket. (10 mins)

Teaching suggestions
• **Special needs.** A sorting activity could be used to help pupils consider why metals are used for a particular purpose.
• **Extension.** Ask pupils to find out about the function of a catalytic converter in a car exhaust.
• **Learning styles**
Visual: Making observations of the arrangements of the bubbles in the alloy modelling.
Auditory: Describing their observations.
Kinaesthetic: Modelling alloys.
Interpersonal: Working with others during practical work.
• **Homework.** Pupils could find out about the material 'Memoflex'. [This alloy is often used to make spectacle frames which can be badly deformed and still return to their original shape. The most common alloy used is 'nitinol', a mixture of nickel and titanium, though there are variations.]

Learning Outcomes
All pupils should be able to state that metals have some similar properties and some different ones.
Most pupils should be able to explain that an alloy is a mixture of metals and that copper is used for wires as it is a good conductor of electricity; aluminium is light which makes it good for making vehicles and planes; and iron (steel) is strong, making it good for building structures.
Some pupils should also be able to
How Science Works
Explain why the manipulation of a model or analogy might be needed to clarify an explanation. (1.1a1)

Additional teachers notes
Equipment and materials required
Per group: Petri dish, 15 cm3 of soap solution (strong enough for bubbles to persist when blown), pipette, spatula (to push bubbles).
Safety
Normal laboratory rules.