Reactivity series of metals

Practical video

Supporting resources

Registered charity number: 207890

Contents

Teacher notes

These resources support the practical video Reactivity series of metals, available here: rsc.li/3baSTPO

The value of experiencing live practical work cannot be overstated. Numerous studies provide evidence of its value in terms of learner engagement, understanding, results and the likelihood of continuing to study chemistry or work in a related field. This video can be used to complement live practical work, as well as helping learners to understand the methods, equipment and skills when they cannot access the lab.

How to use this video

The video and additional resources are designed to be used flexibly, but some suggestions follow.

Flipped learning

Learners view the video ahead of the live practical lesson to help it run more smoothly and keep objectives in focus. This may also help build confidence for some learners and improve their outcomes in the lesson.
Use questions from the set provided as part of the preparation task.

Consolidation and revision

Learners view the video after the practical – this may be directly after the lesson or learners can return to it as part of revision for examinations.

Revisiting a practical with a different focus

A practical experiment can support many learning outcomes. Focussing on just one or two of those in a lesson will help ensure that the aims are achieved. The video could be used to revisit the experiment with a different focus.

Home learning

Whether it is remote teaching, homework, or individual learner absence, the video provides an opportunity to engage with a practical experiment and the associated skills when learners are not in the lab.

Other tips

- **Provide your own commentary**

  Mute the voice over and provide your own commentary. This will allow you to better engage with learners and adapt to the needs and objectives of your lesson.
- **Use questions**

  A set of pause-and-think questions are provided in two formats, one for teacher-led questions and discussion and a student worksheet which can be used independently by learners. Select from these or create your own questions to help engage learners and target specific aims.

Notes on running the practical experiment

The video offers three experiments that investigate the relative reactivity of metals. The first explores the reactions of the alkali metals in water and is a teacher demonstration. Exothermic reactions of metals and acid and metal displacement reactions are experiments that learners can carry out themselves. These investigations may be spread over two or three lessons to make the content manageable.

Technician notes including the equipment list and safety notes are available as a separate document here: rsc.li/3baSTPO. If you are planning to carry out these practicals in the classroom, you will need to carry out your own risk assessment.

The displacement reactions are carried out in microscale using a spotting tile. This minimises the amount of chemicals used. Consider demonstrating the copper(ɪɪ) sulfate reactions on a larger scale, so learners can clearly see a change in the colour of solution – it may be harder to spot in the dimple tray.

TIP: ***You may need to remove the metal in the copper(ɪɪ) sulfate solution to see that it has a brown layer of solid on it – it will look black when in the blue solution.***

In the metal acid reactions observe the recommended concentration for the acid as there will not be a significant temperature rise at lower concentrations. Caution learners against using the thermometer to agitate the metal in the acid as there is a risk of making a hole in the cup as well as damaging the thermometer. This section of the video also raises how to do a fair test.

Printable results tables are provided in this booklet to save time in your practical lessons.

Extension work based on the reactivity of metals practical

To add additional higher level extension to this content, you could introduce an unknown metal and its metal salt and then ask the pupils to do an experiment to find out where it fits in the reactivity series, for example you could use tin and tin(II) sulfate. Learners could repeat the displacement reactions experiment and include the unknown metal and metal sulfate. Tin will be more reactive than copper but less reactive than iron.

Integrated instructions

Printable integrated instructions are provided for learners. These are available as a separate download here: rsc.li/3baSTPO

Integrated instructions use clear numbering, arrows and simple pictograms, like an eye to show where observations are required. These have been developed using cognitive load theory. Integrated instructions remove unnecessary information, and therefore reduce extraneous load on students, which increases their working memory capacity to think about what they are doing and why. Read more about the use of integrated instructions here: rsc.li/2SdSqkQ.

Key terms

Learners will need to have a clear understanding of the following scientific terminology:

- reactivity
- displacement
- enthalpy
- exothermic
- acid
- alkali
- effervescence
- inert
- universal indicator
- group 1

We have included an example Frayer model for introducing the term ‘displacement’. You can find more examples, and tips on how to use Frayer models in your teaching here: rsc.li/2WXtuAz.

Prior knowledge

Learners should be familiar with the periodic table of elements. They should know the definition of an element and be able to identify metals and non-metals using the periodic table.

Learners may have experience of investigating the relative reactivity of some metals at 11–14 using a simplified method, such as counting bubbles in a test tube.

Learners may know the products of a metal + acid reaction and be able to write a word equation. This is recapped in the video and the balanced symbol equations are introduced. Depending on where this topic falls in your scheme of work, learners may not have practised balancing equations.

It is unlikely that learners will have come across displacement prior to 14–16 study.

Redox reactions are introduced in this video, in terms of losing and gaining electrons, with the expectation that learners have covered this before. However, this could be used to develop understanding of redox reactions in further detail after finishing the practical work. Equally, you may take the decision to leave it out at this stage.

There are some questions included which ask learners to balance symbol equations. Depending on where the identification of ions comes in your scheme of work your learners may not have come across this yet. Adapt the questions to make them relevant to the stage and level that you are at.

Common misconceptions

Care should be taken when explaining why there is an increase in reactivity down group 1. This article explodes some myths about these reactions: rsc.li/3r1Dkkg.

A common misconception held about chemical reactions is that reactants 'disappear'. This may be exacerbated with observation of the metals with water or metals with acid. The alkali metals are observed to 'disappear' during the reaction with water. Reinforce that the alkali metal reactions produce soluble metal hydroxides using word and symbol equation to show that the alkali metals have not disappeared. It may be useful to add state symbols to show that the alkali metal reactants were solid whereas the metal hydroxides produced are in aqueous solution.

Learners may have a misconception that acid–metal reactions occur because the acid 'eats away' at the metal as this is their understanding of the term 'corrosive'. Address the misconception by demonstrating that metals less reactive than hydrogen (copper, silver, gold, platinum) will not react with acid. Reinforce the process of neutralisation using word and symbol equations.

Magnesium may not produce as high a temperature change as zinc in the metal and acid reactions but it should be more reactive. This is because of the oxidised film on the outside of the Magnesium. Introduce the idea of metals being oxidised by showing oxidation of lithium, sodium and potassium and discussing everyday oxidation reactions that students will already be familiar with, eg rusting and tarnishing.

Diagnostic multiple-choice questions are a great way to explore students' reasoning behind their answers. Best Evidence Science Teaching resources provide a great starting point to explore their ideas about reactivity of metals. Students are given a question and multiple plausible explanations for an observation. They then choose and justify which explanation they agree with. The resources available on the STEM Learning website include diagnostic questions on reactions in solutions, exothermic and endothermic reactions, neutralisation and periodic patterns – all of which would be useful starting points before learning about the reactivity of metals, see www.stem.org.uk/best/chemistry-earth-science/big-idea-chemical-reactions. You can read more about diagnostic questioning here: rsc.li/3u1kED3.

Intended outcomes

It is important that the purpose of each practical is clear from the outset, defining the intended learning outcomes helps to consolidate this. Outcomes can be categorised as hands on, what learners are going to do with objects, and minds on, what learners are going to do with ideas to show their understanding. We have offered some differentiated suggestions for this practical. You may wish to focus on just one or two, or make amendments based your learners' own needs. (Read more at rsc.li/2JMvKa5.)

Consider how you can share outcomes and evaluation with learners, empowering them to direct their own learning.

	Hands on	Minds on
Effective at a lower level	**Students correctly:** • Follow instructions • Use a spatula and measuring cylinder • Read a temperature on a thermometer • Make observations	**Students can:** • Record observations in a table • Write a word equation for each reaction • Identify which metal is the most reactive in acid by observing the largest temperature rise • Identify which combinations of metal and metal salts give a reaction
Effective at a higher level	**Students correctly:** • Repeat the experiment with an unknown metal in acid • Repeat the experiment with an unknown metal and metal sulfate	**Students can:** • Write a balanced chemical equation for each reaction • Explain why there are colour changes in displacement • Design an experiment to work out the reactivity of an unknown metal

How to use the additional resources

Using the pause and think questions

Pause-and-think questions are supplied in two formats: a teacher version for ‘live’ questioning and a student version which can be used during independent study. The time stamps allow you to pause the video when presenting to a class, or learners to use for active revision.

Teacher version

The questions are presented in a table and you can choose to use as many as appropriate for your class and the learning objectives.

Some questions have two timestamps to allow you to adapt the questions for different classes or scenarios. Pause the videos at the earlier timestamp to ask a question before the answer is given, useful for revision or to challenge learners. Pause at the later timestamp to ask a question reflectively and assess whether learners have understood what they have just heard or seen. This would be useful when introducing a topic, in a flipped learning scenario or when additional support and encouragement is needed.

Think about how you will ask for responses. Variation may help to increase engagement – learners could write and hold up short answers; more complex questions could be discussed in groups.

Not all of the questions will be answered directly as part of the video. Some of the questions will draw on prior learning or will be used to extend learners’ thinking beyond the video content.

Student version

The same questions are offered as a printable worksheet for learners. Use in situations where there is not a teacher present to guide discussion during the video, for example homework, revision or remote learning.

Using the structure strips

Writing about chemistry encourages learners to reflect on their understanding, formulate new ideas and make links between ideas in new ways. Learners also need to practice for longer-answer questions in examinations. Structure strips provide scaffolded prompts and help overcome ‘fear of the blank page’. The learner sticks the strip into the margin of their exercise book or onto an A4 sheet of paper and writes alongside it. Use this long-answer question to consolidate learning after the practical and/or for revision. (Read more at rsc.li/2P0JDlW.)

Long-answer question:

> *A student has a sample of an unknown metal solid, labelled ‘metal x’. The sample is shiny in appearance and grey in colour.*
>
> *Describe two different experiments that the student could carry out to place metal x in the reactivity series. Describe the reactions that would take place and the expected results if metal x is more reactive than copper but less reactive than iron.*
>
> *Suggest an identity for metal x.*

Using the follow-up worksheets

Three follow-up worksheets are provided, one for each experiment in the video. These worksheets could be used to consolidate learning following the practical activity, for example as homework or a revision exercise.

Additional resources

Frayer model: displacement

1. **What does the word displacement mean to you?**

   Where have you come across this word before?

2. **Explore displacement.**

   Dis and placement.

   Can you think of any words which are similar to displacement?

Displacement

4. **Can you explain why this is a displacement reaction?**

Calcium + copper chloride → calcium chloride + copper

3. **Definition of displacement.**

Available in landscape format as editable slide at rsc.li/3tZxFgu.

Pause-and-think questions

Teacher version

Timestamp(s)		Question	Answer/discussion points
00:16	00:22	What property does a metal need to have to make a hot water pipe?	Does not rust. Note that the word rust is associated with iron only and we use the word corrode to describe the process with other metals.
00:26	00:30	What property does a metal need to have to make a food can?	Inert (unreactive) so it doesn't react with the food.
00:36		**Reaction of alkali metals with water**	
00:57	01:01	What is the name of the group 1 metals?	The alkali metals.
01:26	01:30	Why is lithium stored in oil?	So it doesn't react with oxygen or moisture in the air.
02:00	02:02	What do you see when you cut lithium with a knife?	A shiny surface.
02:03	02:07	Why does the shiny surface not last long?	Reacts quickly in air – we can say that it tarnishes in air.
02:07		What does this suggest we are going to find about the reactivity of lithium compared to other metals?	It suggests that lithium is more reactive to start with than other metals.
02:17	02:30	Write down three observations of lithium in water.	Floats and moves slowly around on the surface of the water (note that these two statements are usually the same mark). Fizzes (effervescence). Solid lithium disappears/gets smaller.
02:47	02:56	Why does universal indicator go purple after the reaction has finished?	We are making a soluble alkali solution called lithium hydroxide containing OH^- ions.
03:02	03:07	Write a word equation followed by a symbol equation for the reaction of lithium and water.	Lithium + water → lithium hydroxide + hydrogen $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$
03:28	03:33	What is the difference between cutting lithium and sodium?	It is easier to cut sodium, sodium is a softer metal.
03:44		The newly cut surface of sodium goes duller more quickly in air than lithium. What does this suggest we are going to find about the reactivity of sodium compared to lithium?	It suggests sodium will be more reactive than lithium as it reacts more quickly with air.
04:00	04:08	Write down three observations of sodium in water.	Floats and moves quickly across the water. Fizzes (effervescence). Melts into a ball. Solid metal disappears. (*Melts into a ball will usually be a different mark to solid metal disappears.*)
04:15	04:19	Identify three things from the observations that suggest sodium is more reactive than lithium.	Moves more quickly across the water. Fizzes more vigorously. Melts into a ball.

04:23	04:29	Give two similarities between the reactions of sodium and lithium with water.	Both fizzed. Both metals floated and moved across the surface. Both metals ‘disappeared’.
04:36	04:43	The universal indicator turns purple. Name the alkaline solution that has been produced.	Sodium hydroxide, an alkaline solution.
04:46	04:51	Write a word equation followed by a symbol equation for the reaction of sodium and water.	Sodium + water → sodium hydroxide + hydrogen $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
05:11	05:16	How does cutting potassium compare with sodium and lithium?	It is much easier, because it is much softer.
05:47	06:16	Write down three observations for potassium with water. Put a star against two observations that show it is the most reactive alkali metal.	Floats and moves *very quickly** across the water. Fizzes (effervescence). *Self-ignites with lilac flame.** Potassium disappears.
06:22	06:25	What is the name of the alkali solution that turns the universal indicator purple?	Potassium hydroxide solution.
06:29	06:38	Write a word equation followed by a symbol equation for the reaction of potassium and water.	potassium + water → potassium hydroxide + hydrogen $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$
06:38		What gas is given off in all three reactions described and how would you test for it?	Hydrogen. A lit splint gives a squeaky pop.
06:38	06:43	What is the pattern for the reactivity of the alkali metals going down the group?	Reactivity increases.
06:49		**Reactivity of metals with acid**	
07:05		Why are these reactions described as exothermic?	Heat energy released to the surroundings.
07:12	07:15	Why is an insulated cup used?	To reduce heat loss.
07:40		Why is the presenter bending down to look at the measuring cylinder?	So that she has the meniscus at eye level (and doesn’t introduce parallax error).
07.48	07:56	You are measuring temperature *change*, so what must you make sure you measure?	Starting temperature (and maximum temperature reached).
07:56		Identify the independent variable. Identify the dependent variable.	Type of metal. Temperature *change* (must write the word change).
07:59		Record the starting temperature in your results table.	19.5 °C
08:05		Why do you add a lid (with a hole in)?	To stop heat loss (by convection or evaporation). (The hole is for the thermometer, but is not important for answering a question about heat loss.)
08:17	08:23	Record the final temperature in your table. Calculate the temperature change.	27.0 °C 7.5 °C
08:49	08:55	Identify 3 control variables (for a fair test).	Same volume of acid. Same concentration of acid. Same mass of metal.

09:05	09:10	Complete your results table.	Use your own results or wait until the second time stamp to use the example results from the video.
09:10		Calculate the change in temperature.	Zinc – 7.5 °C Magnesium – 51.0 °C Copper – 0.0 °C Iron – 4.0 °C
09:14		Check your answers (if using the sample results from the video). Why is the temperature change given to 1 decimal place?	Learners will have different answers if using their own results. Discuss the reason for any variation – room temperature, amount of metal powder used, efficacy of insulation, errors in procedure etc. Because the measurement on the thermometer was taken to the nearest 0.5 °C. The answer shows the level of accuracy in the measurements taken.
09:18	09:28	Using your results put the metals in order of reactivity. How are you going to do this?	Mg > Zn > Fe > Cu The metal with the highest temperature rise is the most reactive.
09:38	09:44	Recall the general equation for a reaction between a metal and an acid. What is the common name of the salts produced when using hydrochloric acid?	Metal + acid → a salt + hydrogen *(A common way of remembering this is MASH.)* Chlorides.
10:01	10:06	What gas is formed? How do you know?	Hydrogen. A lit splint gave a squeaky pop.
10:17	10:22	Write the word and chemical equations.	Magnesium + hydrochloric acid → magnesium chloride + hydrogen $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ Zinc + hydrochloric acid → zinc chloride + hydrogen $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ Iron + hydrochloric acid → iron chloride + hydrogen $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$
10:22	10:28	Why didn’t we write an equation for the reaction of copper with hydrochloric acid?	There was no reaction.
10:35		**Metal displacement reactions**	
10:50	10:57	Think back to the metal and acid experiment. Why would it be difficult to put copper in order of reactivity?	It does not react with water or acid. Therefore, you can't work out if it is more or less reactive than any other metal that also does not react with water and acid.
11:02	11:07	What does displacement mean?	A more reactive metal displaces a less reactive metal from its compound. Use the Frayer model in the resources pack to explore this key term further.
11:19		Why is the microscale version better for the environment?	Harmful chemicals. Less volume will be less harmful. Less volume will be easier to dispose of safely.
12:49	12:52	Why did you not need to add magnesium to magnesium sulfate, zinc to zinc sulfate or copper to copper sulfate?	A metal does not displace itself.

13.04	13:17	Write down observations in a results table.	A darker metal has appeared on the surface in column 1 row 2 and 3 and in column 2 row 3. The $CuSO_4$ solution has changed colour. The appearance of bubbles also indicate that a reaction is taking place.
13:25		Summarise the reactions that occurred with: • magnesium • zinc • copper	Mg reacted with two other metal salts $ZnSO_4$ and $CuSO_4$. Zn reacted with one other metal salt $CuSO_4$. Cu did not react.
13:48	14:22	Use the information above to put Mg, Zn and Cu order of reactivity.	The order of reactivity is (from the most reactive) Mg, Zn, Cu.
14:22	14:31	Write word and symbol equations for the three reactions described above.	Magnesium + zinc sulfate → magnesium sulfate + zinc $Mg(s) + ZnSO_4(aq) \rightarrow MgSO_4(aq) + Zn(s)$ Magnesium + copper(II) sulfate → magnesium sulfate + copper $Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$ Zinc + copper(II) sulfate → zinc sulfate + copper $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$
14:36		What is a redox reaction?	A reaction where oxidation and reduction are both taking place.
14:36	14:42	Complete the sentence: The more reactive metal is _________ and the less reactive metal is _________.	oxidised reduced
14:50	15:17	Using the reactions that have taken place, determine the order of reactivity and order the metals from most reactive to least reactive.	potassium sodium lithium magnesium zinc iron copper
15:30		Now try writing a longer answer to this question using the structure strips: A student has a sample of an unknown metal solid, labelled ‘metal *x*’. The sample is shiny in appearance and grey in colour. Describe two different experiments that the student could carry out to place metal *x* in the reactivity series. Describe the reactions that would take place and the expected results if metal *x* is more reactive than copper but less reactive than iron. Suggest an identity for metal *x*.	

Pause-and-think questions

Student version

Pause the video at the time stated to test or revise your knowledge of these practical experiments.

Time **Question**

00:16 Give one property that a metal should have in order to make a hot water pipe.

00:26 Give one property that a metal should have in order to make a food can.

Reaction of metals with water

00:57 What is the name of the group 1 metals? ______________________________

01:26 Why are all the group 1 metals stored in oil?

02:07 Explain what you see when you cut an alkali metal. Why does it not last long?

02:18 Fill in the chart below for the observation of the alkali metals in water.

alkali metal	observation in water
Lithium	
Sodium	
Potassium	

06:16 List two similarities in the observations for the reactions of the alkali metals with water.

1. ______________________________
2. ______________________________

06:16 List two differences for the reaction of potassium with water compared to sodium and lithium.

1. ______________________________
2. ______________________________

06:25 Why does the universal indicator go purple after the reaction of each of the alkali metals in water?

06:38 Complete the word and symbol equations for the reaction of lithium, sodium and potassium with water.

Lithium + water → ____________ + ____________

$2Li(s) + 2H_2O(l) \rightarrow$ _________ + _________

Sodium + ____________ → ____________ + ____________

$2Na(s) + 2H_2O(l) \rightarrow$ _________ + _________

Potassium + water → ____________ + ____________

_________ + _________ → _________ + _________

06:43 Put lithium, sodium and potassium in order of reactivity – most reactive first.

______________________________ > ______________________________ > ______________________________

Describe the trend in reactivity of the group 1 metals.

____

Reaction of metals with acid

07:05 Why are metal reactions with acid described as exothermic reactions?

____

07:15 How do you minimise heat loss during the reaction between metals and acid?

____

____

07:56 Identify the independent variable in a reaction of different metals with acid.

____

Identify the dependent variable in the exothermic reaction of different metals with acid.

____

07:59 Read the temperature and complete the table.

	Temperature °C		
Metal	**Initial**	**Final**	**Change**
Zinc			

08:49 Identify three control variables in this experiment for a fair test.

1. ____
2. ____
3. ____

09:10 Fill in the results chart for the reaction of magnesium, zinc, iron and copper with acid.

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**
Zinc				
Magnesium				
Copper				
Iron				

09:28 What is the order of reactivity of magnesium, zinc, copper, iron putting the most reactive first?

______________________ > ______________________ > ______________________ > ______________________

09:38 The acid used in this experiment is hydrochloric acid. What is the name of the salts that will be produced?

____

10:06 The gas given off is hydrogen. What is the test for this gas?

____

____

10:17 Write a word and symbol equation for the reaction of zinc, iron and magnesium with acid.

Magnesium + hydrochloric acid → ______________________ + ______________________

__________ + __________ → __________ + __________

Zinc + hydrochloric acid → ______________________ + ______________________

__________ + __________ → __________ + __________

Iron + hydrochloric acid → ______________________ + ______________________

__________ + __________ → __________ + __________

10:22 Why don't we write an equation for the reaction of copper with hydrochloric acid?

Metal displacement reactions

11:02 Define displacement.

12:49 Why do you not add magnesium to magnesium sulfate?

13:04 Complete the table with a tick or a cross to indicate where a reaction has taken place.

Metal **Metal salt solution**	**Magnesium**	**Zinc**	**Copper**
Magnesium sulfate			
Zinc sulfate			
Copper(II) sulfate			

13:48 Write down the order of reactivity of magnesium, zinc and copper with the most reactive first.

______________________________ > ______________________________ > ______________________________

14:22 Write the word and symbol equations for the three reactions.

14:36 These reactions are redox equations. Define a redox reaction.

14:36 Complete the sentences using **reduced** and **oxidised**.

The more reactive metal is ______________________ and the less reactive metal is ______________________.

14:50 Using all the results from the three experiments of metals with water, acid and displacement, put the following metals in order of reactivity with the most reactive first:

______________________________ Most reactive

____

____

____

____

____

______________________________ Least reactive

15:30 Now try writing a longer answer to this question using the structure strips:

A student has a sample of an unknown metal solid, labelled ‘metal *x*’. The sample is shiny in appearance and grey in colour.

Describe two different experiments that the student could carry out to place metal x in the reactivity series. Describe the reactions that would take place and the expected results if metal x is more reactive than copper but less reactive than iron.

Suggest an identity for metal *x*.

This question has a structure strip. Find more resources to support you here rsc.li/3baSTPO.

Reactivity of metals Structure strip	Reactivity of metals Structure strip	Reactivity of metals Structure strip	Reactivity of metals Structure strip	Reactivity of metals Structure strip
How can a metal–acid reaction be used to determine reactivity?	How can a metal–acid reaction be used to determine reactivity?	How can a metal–acid reaction be used to determine reactivity?	How can a metal–acid reaction be used to determine reactivity?	How can a metal–acid reaction be used to determine reactivity?
Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.	Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.	Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.	Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.	Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.
Describe and explain the results you would expect to see.	Describe and explain the results you would expect to see.	Describe and explain the results you would expect to see.	Describe and explain the results you would expect to see.	Describe and explain the results you would expect to see.
What is a displacement reaction?	What is a displacement reaction?	What is a displacement reaction?	What is a displacement reaction?	What is a displacement reaction?
Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.	Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.	Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.	Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.	Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.
Suggest an identity for metal *x* using the reactivity series.	Suggest an identity for metal *x* using the reactivity series.	Suggest an identity for metal *x* using the reactivity series.	Suggest an identity for metal *x* using the reactivity series.	Suggest an identity for metal *x* using the reactivity series.

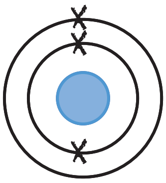
Structure strip: suggested answer content

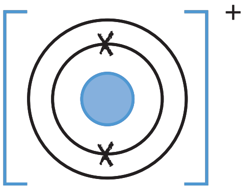
Reactivity of metals **Structure strip**	
How can a metal–acid reaction be used to determine reactivity?	To work out the relative reactivity of metal *x* to both copper and iron you could use a metal–acid neutralisation reaction and a displacement reaction.
Describe a method for metal–acid reaction. Include the measurements you will need to take and the equipment you will use.	A metal–acid neutralisation reaction is exothermic. This means that during the reaction energy is released to the surroundings. We can observe this as a temperature change. The more reactive the metal, the greater the temperature change that will be observed. The general equation for a metal–acid reaction is: metal + acid → metal salt + hydrogen To compare the reactivity of iron, copper and metal *x* you will need to measure 20 cm^3 of hydrochloric acid into an insulated cup with a lid. Measure the starting temperature with a thermometer. Add 1–2 spatulas of the metal powder and wait until the maximum temperature is reached, then record. The temperature change can be calculated by taking the starting temperature away from the maximum temperature reached. Repeat for each metal powder.
Describe and explain the results you would expect to see.	Copper does not react with hydrochloric acid so there will be no change in temperature. Iron reacts with hydrochloric acid so there will be a small temperature change of 4–5 °C. If metal *x* is more reactive than copper but less reactive than iron then it should produce a temperature change between 0–4 °C. However, if metal *x* is less reactive than hydrogen then there will be no reaction and we will not be able to deduce whether copper or metal *x* is the most reactive.
What is a displacement reaction?	To further confirm the relative reactivity of metal *x* we can use a displacement reaction. During a displacement reaction a more reactive metal will displace a less reactive metal from its compound. You will need to use a metal compound in aqueous solution such as iron(II) sulfate solution, copper(II) sulfate solution and metal *x* sulfate solution. You will also need a small piece of iron, copper and metal *x* ribbon.
Describe a method to show the relative reactivity of iron, copper and metal *x* using displacement. Include the chemicals and equipment you will need. What are the expected results? Write an equation for the reactions that take place.	In a test tube or spotting tile you will need to add a small piece of metal *x* to iron(II) sulfate solution and copper(II) sulfate solution. If metal *x* is more reactive than copper then there should be a displacement reaction: metal *x* + copper sulfate → copper + metal *x* sulfate You will observe a brown precipitate of copper forming and the solution may change colour. If metal *x* is less reactive than iron then there should be no reaction with the iron(II) sulfate. Next you should add a small piece of copper and a small piece of iron to a few drops of metal *x* sulfate. If metal *x* is more reactive than copper then there should be no reaction. If metal x is less reactive than iron then the iron will displace metal *x* from the compound: iron + metal *x* sulfate → metal *x* + iron sulfate You will observe a grey precipitate of metal *x* forming and the solution may change colour.
Suggest an identity for metal *x* using the reactivity series.	Metal *x* is a grey coloured shiny metal which is more reactive than copper but less reactive than iron. A possible identity, using the reactivity series of metals, for metal *x* could be lead, nickel or tin.

Follow-up worksheet: alkali metals

1. Group 1 metals react by losing an electron. The diagrams below show a lithium atom and a lithium ion. Complete the electron configuration diagrams for sodium and potassium atoms and ions.

7
Li
Lithium
3

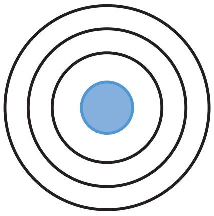


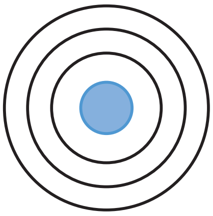


Li (atom) **Li^+ (ion)**

Electron configuration: **2,1** **2,0**

23
Na
Sodium
11





Na (atom) **Na^+ (ion)**

Electron configuration:

39
K
Potassium
19

K (atom) **K^+ (ion)**

Electron configuration:

Look at the electron diagrams that you have drawn and answer the following questions:

2. What do you notice about the electron configuration of the ions?

3. Why do the group 1 metals lose an electron when they react?

4. Is losing an electron, oxidation or reduction?

5. Use your answer to Q3 to identify whether the group 1 metals are good reducing agents or oxidising agents. Explain your answer.

6. How can you tell from the electron configuration that these atoms are in group 1?

7. By looking at the electron configuration how can you tell which period atoms are in?

8. Identify which period the following elements belong to:

a. Lithium ____________________

b. Sodium ____________________

c. Potassium ____________________

9. As you go down group 1 what happens to the size of the atoms? How can you tell this?

10. From the video, which group 1 metal was the most reactive?

11. Use the information above and the diagrams you have drawn in Q1 to explain why potassium is the most reactive of these three alkali metals.

12. From the video, describe the pattern for how easy it was to cut the Li, Na and K.

13. Using your answer from Q12, describe the pattern in softness as you move down group 1. Make a prediction linking softness to melting point.

14. All three alkali metals, Li, Na, K float on water. What does this indicate about the density of these alkali metals compared to water?

15. The density of water = 1.0 g cm^{-3}. The density of the alkali metals is as follows:

Element	Density g cm^{-3}
Lithium, Li	0.534
Sodium, Na	0.971
Potassium, K	0.862
Rubidium, Rb	1.532
Caesium, Cs	1.873

Do all the alkali metals float on water? Explain your answer.

16. When a group 1 metal reacts with water a metal hydroxide is formed. This is an ionic compound containing two ions, a negative and a positive ion, in a giant lattice.

Which ions are in sodium hydroxide?

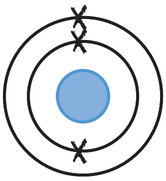
17. Draw a simple diagram to show how these ions are arranged in the giant lattice for the sodium hydroxide. You can use one circle for each type of ion.

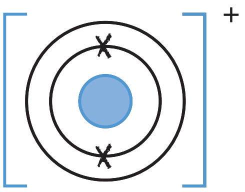
18. Challenge: draw a dot and cross diagram for the hydroxide ion. You can draw outer shells only. Remember to include the charge on the ion.

Follow-up worksheet: alkali metals

1. Group 1 metals react by losing an electron. The diagrams below show a lithium atom and a lithium ion. Complete the electron configuration diagrams for sodium and potassium atoms and ions.

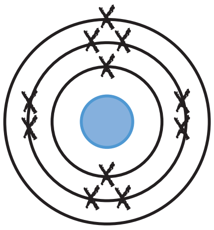
7
Li
3

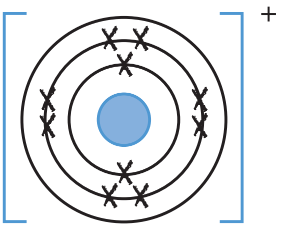




	Li (atom)	**Li$^+$ (ion)**
Electron configuration:	**2,1**	**2,0**

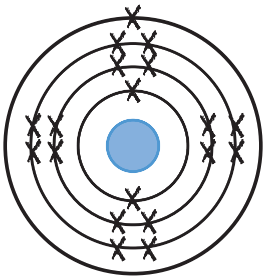
23
Na
11

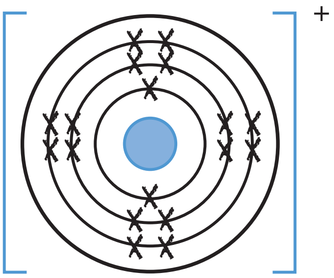




	Na (atom)	**Na$^+$ (ion)**
Electron configuration:	**2,8,1**	**2,8**

39
K
19





	K (atom)	**K$^+$ (ion)**
Electron configuration:	**2,8,8,1**	**2,8,8**

Look at the electron diagrams that you have drawn and answer the following questions:

2. What do you notice about the electron configuration of the ions?

   It is the electron configuration of a noble gas.

3. Why do the group 1 metals lose an electron when they react?

   The atom then has a full outer shell of electrons.

4. Is losing an electron, oxidation or reduction

   Oxidation is loss of an electron.

5. Use your answer to Q2 to identify whether the group 1 metals are good reducing agents or oxidising agents. Explain your answer.

   The metal loses an electron which it can give to another atom. The group 1 metals are therefore good reducing agents.

6. How can you tell from the electron configuration (or the diagram with added electrons in), that these atoms are in group 1?

   The atoms have one electron in their outer shell

7. By looking at the electron configuration, how can you tell which period the atoms are in?

   The period corresponds to the number of shells that have electrons in.

8. Identify which period Li, Na and K are in.

   Li – period 2

   Na – period 3

   K – period 4

9. As you go down group 1 what happens to the size of the atoms? How can you tell this?

   The atoms get bigger. The atoms have more electrons filling more shells.

10. From the video which group 1 metal (Li, Na or K) was the most reactive.

    Potassium

11. Use the information above and the diagrams you have drawn in Q1 to explain why potassium is the most reactive out of these three alkali metals.

    The atoms get bigger as you go down the group, and there are more shells filled with electrons. These electrons layers shield the outer electron from the nucleus, so we say it has increased shielding. The outer electron is further from the nucleus so there is less attraction, and it is more easily removed.

12. From the video, describe the pattern for how easy it was to cut the Li, Na and K.

    It was easier to cut each alkali metal as you went down the group (Li was the hardest to cut, K the easiest).

13. Using your answer from Q12, describe the pattern in softness as you move down group 1. Make a prediction linking softness to melting point.

    The alkali metals get softer as you go down the group. The softer metals are easier to melt so melting point decreases down the group.

Element	Melting point °C
Lithium, Li	**180**
Sodium, Na	**98**
Potassium, K	**63**
Rubidium, Rb	**39**
Caesium, Cs	**28**

14. All three alkali metals, Li, Na, K float on water. What does this indicate about the density of these alkali metals?

The density of Li, Na and K must be less than the density of water.

15. The density of water = 1.0 g cm^{-3}. The density of the alkali metals is as follows:

Element	Density g cm^{-3}
Lithium, Li	0.534
Sodium, Na	0.971
Potassium, K	0.862
Rubidium, Rb	1.532
Caesium, Cs	1.873

Do all the alkali metals float on water? Explain your answer.

No, Rb and Cs have a density greater than 1 (water) and so they will sink.

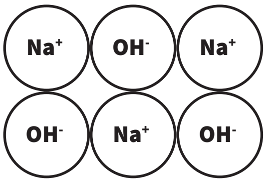
16. When a group 1 metal reacts with water a metal hydroxide is formed. This is an ionic compound containing two ions, a negative and a positive ion, in a giant lattice.

Which ions are in sodium hydroxide?

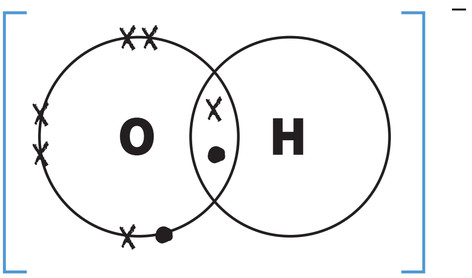
Na^+ (sodium ion) and OH^- (hydroxide ion).

17. Draw a simple diagram to show how these ions are arranged in the giant lattice for the sodium hydroxide. You can use one circle for each type of ion.

The positive and negative ions are arranged alternatively in rows in a giant 3D lattice.



18. Challenge: draw a dot and cross diagram for the hydroxide ion. You can draw outer shells only. Remember to include the charge on the ion.



Follow up worksheet: reactions of metals with acids

1. What is the general equation for the reaction of a metal with an acid?

   ______________________ + ______________________ → ______________________ + ______________________

2. What type of reaction is this? (Circle all that are correct.)

   displacement neutralisation redox decomposition

3. Match the acid to the salt produced.

   Hydrochloric acid

   Sulfuric acid

   Nitric acid

   nitrate salts

   chloride salts

   sulfate salts

4. Balance the following symbol equations for reactions of metals with acid:

   ____ Mg + _____ HCl → _____ $MgCl_2$ + _____ H_2
   ____ Fe + _____ HCl → _____ $FeCl_2$ + _____ H_2
   ____ Zn + _____ H_2SO_4 → _____ $ZnSO_4$ + _____ H_2
   ____ Na + _____ H_2CO_3 → _____ Na_2CO_3 + _____ H_2*

   Challenge 1

   ____ Ca + _____ HNO_3 → _____ $Ca(NO_3)_2$ + _____ H_2
   ____ Zr + _____ H_2SO_4 → _____ $Zr(SO_4)_2$ + _____ H_2**

   Challenge 2

   ____ Fe + _____ HCl → _____ FeCl3 + _____ H_2
   ____ Al + _____ H_2SO_4 → _____ $Al_2(SO_4)$ + _____ H_2
   ____ Fe + _____ HNO_3 → _____ $Fe(NO_3)_3$ + _____ H_2

   Fun Trivia!

   ***H_2CO_3 is carbonic acid. You don't come across this acid very often at 14–16, but it follows the same general equation when reacting with a metal.**

   ****Zirconium does not readily react with sulfuric acid unless at very high temperatures and in a sealed container.**

5. Iron can react with hydrochloric acid to give iron(II) chloride or iron(III) chloride. What is the charge on the iron(II) and iron(III) ions?

   a. Iron(II): __________
   b. Iron(III): __________

Follow up worksheet: reactions of metals with acids ANSWERS

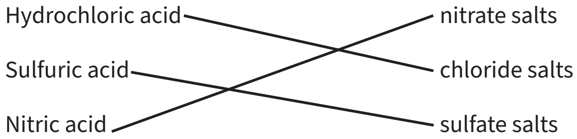
1. What is the general equation for the reaction of a metal with an acid?

   metal + acid → a salt + hydrogen

2. What type of reaction is this? (Circle all that are correct.)

   displacement [✓ **neutralisation**] [✓ **redox**] decomposition

3. Match the acid to the salt produced.



4. Balance the following symbol equations for reactions of metals with acid:

   ____ Mg + __**2**__ HCl → _____ $MgCl_2$ + _____ H_2

   ____ Fe + __**2**__ HCl → _____ $FeCl_2$ + _____ H_2

   ____ Zn + _____ H_2SO_4 → _____ $ZnSO_4$ + _____ H_2 *no balancing required*

   _ **2** _ Na + _____ H_2CO_3 → _____ Na_2CO_3 + _____ H_2*

   Challenge 1

   ____ Ca + __**2**__ HNO_3 → _____ $Ca(NO_3)_2$ + _____ H_2

   ____ Zr + __**2**__ H_2SO_4 → _____ $Zr(SO_4)_2$ + __**2**__ H_2**

   Challenge 2

   _ **2** _ Fe + __**6**__ HCl → __**2**__ FeCl3 + __**3**__ H_2

   _ **2** _ Al + __**3**__ H_2SO_4 → _____ $Al_2(SO_4)$ + __**3**__ H_2

   _ **2** _ Fe + __**6**__ HNO_3 → __**2**__ $Fe(NO_3)_3$ + __**3**__ H_2

   Fun Trivia!

   ***H_2CO_3 is carbonic acid. You don't come across this acid very often at 14–16, but it follows the same general equation when reacting with a metal.**

   ****Zirconium does not readily react with sulfuric acid unless at very high temperatures and in a sealed container.**

5. Iron can react with hydrochloric acid to give iron(II) chloride or iron(III) chloride. What is the charge on the iron(II) and iron(III) ions?

   a. Iron(II): **Fe^{2+}**

   b. Iron(III): **Fe^{3+}**

Follow up worksheet: metal displacement reactions

The following word equations show a reaction of metals with a metal salt. Using the reactivity series of metals decided whether or not a displacement reaction would occur.

If a reaction would occur then complete the word equation and balanced symbol equations.

Reaction?
✔ or ✘

1. magnesium + zinc chloride → ______________________________ + ______________________________ ☐

______Mg + ______$ZnCl_2$ → ______________ + ______________

2. copper + zinc sulphate → ______________________________ + ______________________________ ☐

______Cu + ______$ZnSO_4$ → ______________ + ______________

3. lithium + sodium chloride → ______________________________ + ______________________________ ☐

______Li + _______$NaCl$ → ______________ + ______________

4. iron(iii) + copper(ii) sulfate → ______________________________ + ______________________________ ☐

______Fe + ______$CuSO_4$ → ______________ + ______________

5. potassium + lithium nitrate → ______________________________ + ______________________________ ☐

______K + _______$LiNO_3$ → ______________ + ______________

6. copper + gold(ii) sulfate → ______________________________ + ______________________________ ☐

______Cu + ______$AuSO_4$ → ______________ + ______________

7. zinc + iron(iii) sulfate → ______________________________ + ______________________________ ☐

______Zn + ______$Fe_2(SO_4)_3$ → ____________ + ______________

8. sodium + potassium nitrate → ______________________________ + ______________________________ ☐

______Na + ______KNO_3 → ______________ + ______________

9. magnesium + iron(III) chloride → ______________________________ + ______________________________ ☐

______Mg + ______$FeCl_3$ → ______________ + ______________

10. iron(iii) + lead(ii) sulfate → ______________________________ + ______________________________ ☐

______Fe + ______$PbSO_4$ → ______________ + ______________

Follow up worksheet: metal displacement reactions ANSWERS

The following word equations show a reaction of metals with a metal salt. Using the reactivity series of metals decided whether or not a displacement reaction would occur.

If a reaction would occur then complete the word equation and balanced symbol equations.

Reaction?
✔ or ✘

1. magnesium + zinc chloride → **magnesium chloride + zinc** ☑

______Mg + ______$ZnCl_2$ → **$MgCl_2$ + Zn**

2. copper + zinc sulphate → ______________________________ + ________________________ ☒

______Cu + ______$ZnSO_4$ → ______________ + ______________

3. lithium + sodium chloride → ___________________________ + ________________________ ☒

______Li + _______NaCl → ______________ + ______________

4. iron(iii) + copper(ii) sulfate → **iron(II) sulfate + copper** ☑

______Fe + ______$CuSO_4$ → **$FeSO_4$ + Cu**

5. potassium + lithium nitrate → **potassium nitrate + lithium** ☑

______K + _______$LiNO_3$ → **KNO_3 + Li**

6. copper + gold(ii) sulfate → **copper(II) sulfate + gold** ☑

______Cu + ______$AuSO_4$ → **$CuSO_4$ + Au**

7. zinc + iron(iii) sulfate → **zinc sulfate + iron** ☑

3Zn + ______$Fe_2(SO_4)_3$ → **3$ZnSO_4$ + 2Fe**

8. sodium + potassium nitrate → __________________________ + ________________________ ☒

______Na + ______KNO_3 → ______________ + ______________

9. magnesium + iron(III) chloride → **magnesium chloride + iron** ☑

3Mg + **2**$FeCl_3$ → **3$MgCl_2$ + 2Fe**

10. iron(iii) + lead(ii) sulfate → **iron(III) sulfate + lead** ☑

2Fe + **3**$PbSO_4$ → **$Fe_2(SO_4)_3$ + 3Pb**

Table for reaction of alkali metals with water

Alkali metal	**Observation when added to water**	
Lithium	*Similarities*	*Differences*
Sodium	*Similarities*	*Differences*
Potassium	*Similarities*	*Differences*

Tables for reactions of metals with acids

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**
Zinc				
Magnesium				
Copper				
Iron				

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**
Zinc				
Magnesium				
Copper				
Iron				

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**
Zinc				
Magnesium				
Copper				
Iron				

Blank tables for reactions of metals with acids

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**

		Temperature °C		
Metal	**Observation with acid**	**Initial**	**Final**	**Change**

Results tables for metal displacement reactions

Metal Metal salt solution	Magnesium	Zinc	Copper
Magnesium sulfate			
Zinc sulfate			
Copper(II) sulfate			

Metal Metal salt solution	Magnesium	Zinc	Copper
Magnesium sulfate			
Zinc sulfate			
Copper(II) sulfate			

Metal Metal salt solution	Magnesium	Zinc	Copper
Magnesium sulfate			
Zinc sulfate			
Copper(II) sulfate			