Cambridge Assessment International Education

Teaching Pack

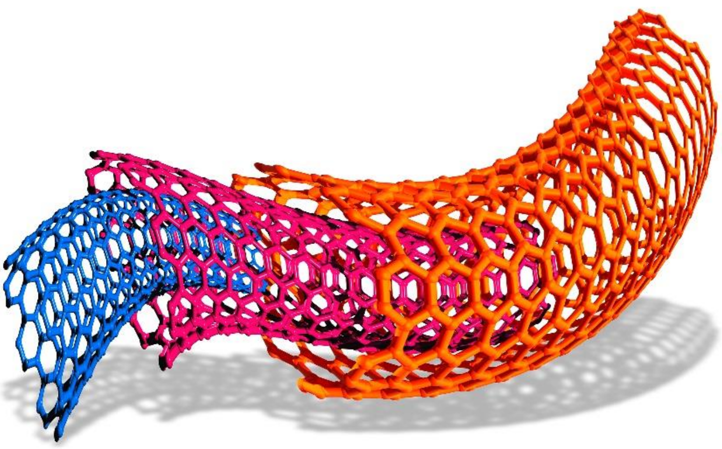
The extraction of iron on a match head

Cambridge IGCSE™

Combined Science 0653

This Teaching Pack can also be used with the following syllabuses:

- Cambridge IGCSE™ (9–1) Chemistry **0971**
- Cambridge IGCSE™ Chemistry (US) **0439**
- Cambridge IGCSE™ Physical Science **0652**
- Cambridge IGCSE™ Chemistry **0620**
- Cambridge IGCSE™ Co-ordinated Sciences (Double Award) **0654**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge O Level Chemistry **5070**
- Cambridge O Level Combined Science **5129**



Version 2.0

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

Lab option 1 – run the experiment

Lab option 2 – virtual experiment

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note

Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases this also includes the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: The extraction of iron on a match head

This *Teaching Pack* focuses on a metal extraction.

A number of metals, lower in the reactivity series than carbon, can be extracted by heating with carbon. This is a redox reaction. In this pack, learners will design an experiment to extract iron on a small scale and revise redox reactions.

This experiment has links to the following syllabus content (see syllabus for detail):

- C7.2 Redox
- C10.2 Reactivity series
- C10.3 Extraction of metals

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)
- plan experiments and investigations
- evaluate methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- C7.2 Redox
- C10.2 Reactivity series

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners about the extraction of aluminium by electrolysis.

Briefing lesson: Planning the extraction experiment

Resources	• Worksheets A and B • a piece of iron ore (or an image of it)

Learning objectives	By the end of the lesson: • ***all*** learners should have drawn their lab design • ***most*** learners should have drawn their lab design and annotated it. • ***some*** learners will also be able to explain to the rest of the class how the experiment works.

Timings	Activity
10 min	**Starter/Introduction** Hand out Worksheet A. In pairs, get learners to consider the reactions of seven different metals with dilute acids, water/steam and air. After cutting out the rows with the descriptions of the reactions for each metal, learners arrange them in order of decreasing reactivity. To conclude the activity, ask volunteers to explain their order. Compare class results, and write the correct reactivity series on the board for reference later on.
5 min 5 min 30 min	**Main lesson** Show learners a piece of iron ore e.g. a piece of haematite (or an image of it from the internet), explaining to them that an ore is a rock that after purification yields the elemental metal. Ask the learners why it does not look like the metal they know, and explain to them that it is not pure and/or it exists as a compound of the metal that must be extracted to get it in its elemental form. Ask the learners how they might extract the metal from the ore. *Suggestions may include: heating, crushing, chemical reactions – all of which can be correct.* Explain to the learners that a common method of extracting certain metals from their ores is to heat the metal ore with carbon. The carbon combines with the oxygen in the ore and removes it, leaving the desired metallic element. *Reduction is dealt with more fully in the lab lesson and debriefing lesson later in this pack.* For now, it is sufficient to explain to the learners that they will be taking some iron ore (iron(III) oxide) and trying to extract elemental iron from it on a very small scale. Supply them with the following information: *You will be given a small amount of iron(III) oxide on a watch glass, a match, a beaker of water, a pair of metal tongs, a Bunsen burner, a heatproof mat, a mortar and pestle and a magnet.* Their task is to devise a method in order to perform the experiment. You will need to explain to the learners that the carbon needed for the experiment, comes from the match itself. *Continues on next page …*

Timings	Activity
	Hand out Worksheet B. With appropriate guidance, get learners to work in pairs drawing their designs in the space provided. Stress that **all** of the equipment/materials must be used and that their diagrams must be fully annotated.
	**Plenary** Now they have drawn their equipment, ask learners to write out a safety briefing that explains to others how to use their equipment safely. *In particular safety with matches and Bunsen burners should be highlighted.* Do not forget to remind learners to also include general good practice in the lab, including things like tying back long hair, wearing goggles, not eating or drinking, etc.

Lab lesson: Option 1 – run the experiment

Resources

- Teacher notes
- *Teacher Walkthrough video*
- Worksheets B, C, D and E
- Equipment as outlined in the notes

Learning objectives

By the end of the lesson:

- ***all*** learners should be able to extract iron from the iron(III) oxide and test the product with a magnet
- ***most*** learners should be able to extract iron from the iron(III) oxide, test the product with a magnet and be able to explain the origin of the carbon needed for the reduction
- ***some*** learners will additionally be able to explain what the function of the carbon is in the reaction.

Timings	Activity
5 min	**Starter/Introduction** Ask the learners some general questions about the experiment they planned in the previous lesson. 1. What type of chemical bonding exists in iron(III) oxide? *ionic bonding* 2. What form does the iron exist in? *as positive ions* 3. Why can't the iron be physically removed from the iron(III) oxide using a magnet? *because the iron ions are attracted strongly to the oxide ions in a lattice* 4. What functions does the match have in this experiment? *it supplies heat for the reaction to occur and also carbon for the reduction reaction*
10 min	**Main lesson** Arrange the learners in groups of 2–3. Hand out Worksheet C. Learners compare the annotated diagram of the set-up from the planning activity (on completed Worksheet B) with the diagram of the experiment to be performed now (Worksheet C). Ask the learners what the significant differences are: i. Explain that because the quantities of materials used are so small in this experiment, a mortar and pestle is not used. Instead the match head, after the reaction, is carefully crushed on a watch glass using a spatula. ii. Explain that sodium carbonate does not take part in the reaction but fuses easily and brings the carbon into contact with the iron(III) oxide. **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe.
10 min	1. Learners perform the experiment following the instructions on Worksheet C carefully. 2. Next they are given Worksheet D, where learners write their results and evaluate the experiment. Discuss the answers with the learners using the suggested answers.
15 min	Once learners have completed the experiment ask them to work in pairs and give them Worksheet E. Learners should consider the reactants and products of the reaction and write a word and balanced equation for the reaction. *Continues on next page …*

Timings	Activity
15 min	Remind learners of the terms *oxidation* and *reduction* (redox reactions). Explain to them that the removal of oxygen from a compound is called *reduction*. Re-write the reactivity series from the previous lesson and insert the position of carbon in it. Once inserted, ask learners which is the more reactive, iron or carbon. *carbon is above iron and their answer should be 'more reactive'* Explain to the learners that because carbon is more reactive than iron, it is capable of reducing the iron(III) oxide and removes oxygen from it – it is a *reducing agent*. Finally point out that the addition of oxygen is *oxidation*. Learners should therefore be able to identify which substance has been oxidised and which has been reduced. Further definitions of redox will be discussed in the debriefing session.
5 min	**Plenary** Show an image of lead(II) oxide (PbO). Ask learners, using the knowledge they have gained, what they would have to do to get lead metal from it. They should mention that a reducing agent (carbon) is needed and that the two materials should be heated together causing lead(II) oxide to be reduced to lead metal. If time allows, learners could try to write the balanced equation for the reaction, and then volunteers write it on the board, for example: oxidation (C → CO_2) $2PbO(s) + C(s) \rightarrow 2Pb(s) + CO_2(g)$ reducing agent (C) reduction (PbO → Pb)

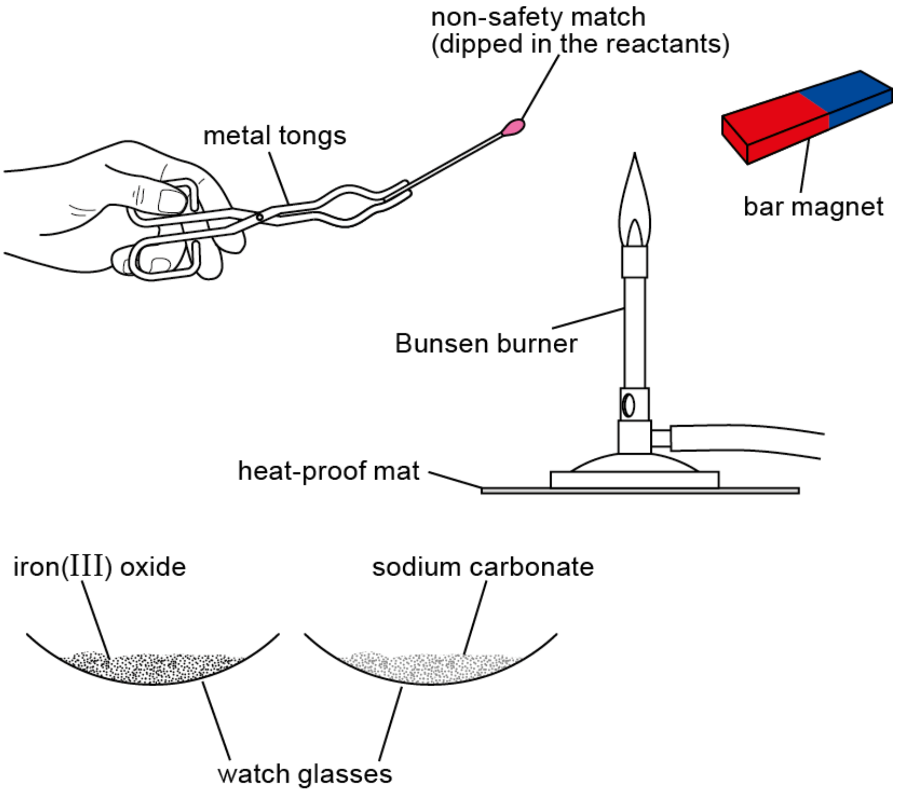
Teacher notes

Watch the *Teacher walkthrough* video for the extraction of iron on a match and read these notes.

Each group (or pair) will require:

- a non-safety match
- a spatula load of iron(III) oxide on a watch glass
- a spatula load of sodium carbonate on watch glass
- a small beaker of water
- a Bunsen burner
- a pair of crucible tongs
- a heatproof mat
- a flat metal spatula.

Experiment set-up



Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.
It is your responsibility to carry out an appropriate risk assessment for this experiment.

Substance	Hazard	First aid
Sodium carbonate (solid)	 GHS07 *(moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for 10 min. See a doctor if pain persists. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** brush solid off contaminated clothing. Rinse clothing or the skin as necessary. **Spilt on the floor, bench, etc.:** brush up solid spills, trying to avoid raising dust, then wipe with a damp cloth. Wipe up solution spills with a cloth and rinse it well.
Iron(III) oxide (solid)	 GHS07 *(moderate hazard* **MH**)	**In the eye:** flood the eye with gently-running tap water for at least 10 min. See a doctor. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** remove contaminated clothing and rinse it. Wash off the skin with plenty of water. **Spilt on the floor, bench, etc.:** Scoop up solid (take care not to raise dust). Wipe up small solution spills or any traces of solid with cloth; for larger spills use mineral absorbent (e.g. cat litter).
	Burns	Flood burnt area with water for at least 10 min. For serious injuries see a doctor.

Teacher method

This is your version of the method for this experiment that accompanies the *Teacher walkthrough* video.

Do not share this method with learners. Give them Worksheet C, Worksheet D and Worksheet E.

Before you begin
Plan how you will group your learners during the experiment session.

Think about:
- the number of groups you will need (group size 2–4 learners)
- the amount of equipment/chemicals required

Experiment
Walk around the learners during the experiment in case they encounter any difficulties.

<u>Steps</u>	<u>Notes</u>
1. Check that learners have the chemicals and equipment they need in front of them.	*The match could be handed out last, just before the learners are due to start the experiment.*
2. Check that the learners have Worksheet C and Worksheet D.	
3. Before they start, warn the learners about safety and good practice for this experiment.	*Check that they use the blue flame for the test and return the Bunsen burner back to the safety flame afterwards.*
4. Place small amounts of each chemical on to separate watch glasses.	
5. Check that neither of the starting materials are magnetic. Move a magnet underneath the watch glasses.	*Warn learners against moving the magnet above the watch glasses (unless it is covered in cling-film). Warn them that they only have one match which is not to be struck beforehand.*
6. Dip the head of the match into water.	
7. Roll the moistened match head in the sodium carbonate.	*It should be coated completely.*
8. Next roll the match head in the iron(III) oxide.	*The match head should look completely covered in the red-brown powder after doing this.*
9. Grip the match firmly between metal crucible tongs.	

10. Adjust the Bunsen burner to a blue flame.

11. Ignite the match in the flame and allow it to burn half its length.

12. Allow the match to cool on a heat proof mat.

Do not forget to turn the Bunsen burner off.

13. The charred part of the match head is now crushed using a spatula on a watch glass.

Do not apply too much pressure; the head will crush very easily.

14. A magnet is moved around underneath the watch glass.

The iron which has been produced should follow the path of the magnet. Again, warn learners against moving the magnet above the watch glasses (unless it is covered in cling-film).

15. Remind learners not to forget to compare what the starting materials looked like to the resulting crushed match head at the end of the experiment.

Learners should be able to observe that the initial red-brown colour of the iron (III) oxide is now absent.

16. Learners record their results on Worksheet D where they also evaluate the experiment.

Question 6 may prove quite challenging and learners could need guidance completing it.

Clean-up

After the experiment learners should:

- clean all glassware
- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment and any unused chemicals to you.

The very small amounts of solids from this experiment can safely be disposed of in the bin.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual Experiment video* for extraction of iron on a match head • Worksheets B, D and E

Learning objectives	By the end of the lesson: • ***all*** learners should be able to explain how to extract iron from the iron(III) oxide and how to test the product with a magnet • ***most*** learners should be able to explain how to extract iron from the iron(III) oxide and explain how to test the product with a magnet and be able to explain the origin of the carbon needed for the reduction • ***some*** learners will additionally be able to explain what the function of the carbon is in the reaction.

Timings	Activity
5 min	**Starter/Introduction** Ask the learners some general questions about the experiment they planned in the previous lesson. 1. What type of chemical bonding exists in iron(III) oxide? *Ionic bonding* 2. What form does the iron exist in? *As positive ions* 3. Why can't the iron be physically removed from the iron(III) oxide using a magnet? *Because the iron ions are attracted strongly to the oxide ions in a lattice* 4.What functions does the match have in this experiment? *It supplies heat for the reaction to occur and also carbon for the reduction reaction*
	Main lesson Show the *Virtual Experiment video* from start to finish once through without stopping. In pairs, learners discuss the annotated diagram of the set-up from the planning activity (on completed Worksheet B) with the video of the experiment they have just seen. The main differences are: 1. that because the quantities of materials used are so small in this experiment, a mortar and pestle is not used. Instead the match head, after reaction, is carefully crushed on a watch glass using a spatula 2. that sodium carbonate does not take part in the reaction but fuses easily and brings the carbon into contact with the iron(III) oxide. Give each learner a copy of Worksheet D, allowing them time to look through and understand the questions. They should not write anything at this stage. Show the video again to the learners, stopping the video as necessary. Learners then work in pairs to try to complete the sheet, helping each other when required. Project the answer sheet and go over the answers, allowing learners time to correct any mistakes. The learners work in pairs and each are handed a copy of Worksheet E. Ask learners to consider the reactants and products of the reaction and write a word and balanced equation for the reaction. *Continues on next page …*

Timings	Activity
	Remind learners of the terms oxidation and reduction (redox reactions). Explain to them that the removal of oxygen from a compound is called *reduction*. Re-write the reactivity series from the previous lesson and insert the position of carbon in it. Once inserted, ask learners which is the more reactive, iron or carbon. *carbon is above iron and their answer should be 'more reactive'* Explain to the learners that because carbon is more reactive than iron, it is capable of *reducing* the iron(III) oxide and removes oxygen from it – it is a *reducing agent*. Finally point out that the addition of oxygen is *oxidation*. Learners should therefore be able to identify which substance has been oxidised and which has been reduced. Further definitions of redox will be discussed in the debriefing session.
	**Plenary** Show an image of lead(II) oxide (PbO). Ask learners, using the knowledge they have gained, what they would have to do to get lead metal from it. They should mention that a reducing agent (carbon) is needed and that the two materials should be heated together causing lead(II) oxide to be reduced to lead metal. If time allows, learners could try to write the balanced equation for the reaction, and then volunteers write it on the board, for example: oxidation $2PbO(s) + C(s) \rightarrow 2Pb(s) + CO_2(g)$ reducing agent reduction

Debriefing lesson: Identifying redox reactions

Resources	• Worksheets F and G • A sample (or image of) aluminium ore (bauxite)
Learning objectives	By the end of the lesson: • ***all*** learners should be able to identify at least one flaw in the planning experiment and be able to explain a redox change using one of the main methods. • ***most*** learners should be able to identify most of the flaws in the planning experiment, and be able to explain a redox change using one of the main methods • ***some*** learners will be able to identify all of the flaws in the planning experiment, write an effective modified plan and be able to explain redox changes using both methods.

Timings	Activity
10 min	**Starter/Introduction** Ask learners to arrange themselves in pairs and give each pair the following reaction written on a small slip of paper. $2MgO(s) \quad + \quad C(s) \quad \rightarrow \quad 2Mg(s) \quad + \quad CO_2(g)$ Ask them to explain why this reaction will not produce magnesium metal. *Learners should make reference to the fact that magnesium is above carbon in the reactivity series and therefore carbon cannot reduce magnesium oxide to magnesium metal.* Mention to learners that *reduction* using carbon is limited to those metal ores that are below it in the reactivity series and that other methods are employed to produce magnesium e.g. electrolysis.
15 min	**Main lesson** Review redox reaction ideas with learners using both **O**xidation **I**s **L**oss, **R**eduction **I**s **G**ain 'OILRIG' and 'OXIDATION STATES' methods. **OILRIG** By looking at the chemical equation in the starter to this lesson, learners work in pairs to show what is happening to magnesium in terms of electrons. They need to write a half-equation for the reaction: $Mg^{2+} \quad + \quad 2e^- \quad \rightarrow \quad Mg$ *(this is a gain of electrons)* Ask learners what has been oxidised? *Carbon* Why can we not write a half-equation for the oxidation? *Because carbon dioxide is covalently bonded* *Continues on next page …*

Timings	Activity
25 min	**OXIDATION STATES** How can we show the oxidation of carbon to carbon dioxide using oxidation states? $2MgO(s) + C(s) \rightarrow 2Mg(s) + CO_2(g)$ 0 *changing to* +4 Why is this an oxidation reaction? *Because the oxidation state has increased.* Are we able to show the reduction in the same way? *Yes, magnesium in magnesium oxide has an oxidation state of +2 which changes to 0 in elemental magnesium. This is a decrease in oxidation state, which is reduction.* $2MgO(s) + C(s) \rightarrow 2Mg(s) + CO_2(g)$ +2 *changing to* 0 Learners need practice in using the various definitions of redox in the context of metal extraction. Hand out Worksheet F to the learners, who work in pairs for this activity. In part A, learners focus on trying to find out the flaws in an extraction experiment, written by another learner. In part B they use 'OILRIG' and 'OXIDATION STATES' to show evidence that reduction and oxidation occur in the extraction process.
10 min	**Plenary** Discuss useful metals in general with learners. Whilst doing this, project a copy of the extended reactivity series (Worksheet G). Ask learners to look around them and think about the world in general. Ask them 'Which very common metal that is used today cannot be made by extraction with carbon?' *Aluminium* Show learners an image (or sample) of the main ore of aluminium (bauxite). Ask them how it is extracted. *By electrolysis* If time allows a discussion can be had about this process. Finally, ask learners which metals do not need to be extracted at all. *Platinum, gold, silver*

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson*:		
A: Reactivity series starter	**20**	**32**
B: Planning the extraction of iron experiment	**21–22**	—
For use in *Lab lesson: Option 1*:		
B: Planning the extraction of iron experiment	**21–22**	—
C: Experimental set-up and method	**23–24**	—
D: Results and evaluation	**25–26**	**33**
E: Chemical equation for the reaction	**27–28**	—
For use in *Lab lesson: Option 2*:		
B: Planning the extraction of iron experiment	**21–22**	—
D: Results and evaluation	**25–26**	**33**
E: Chemical equation for the reaction	**27–28**	**34**
For use in the *Debriefing lesson*:		
F: Planning and using redox	**29–30**	**35–36**
G: The extended reactivity series	**31**	—

Worksheet A: Reactivity series starter

The table below shows the reactivity of several different metals with water/steam, dilute acids and air.

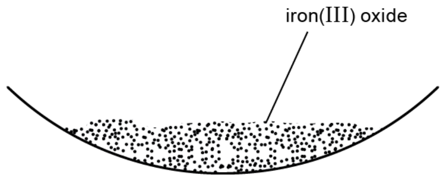
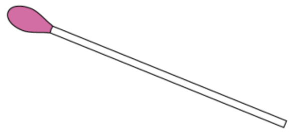
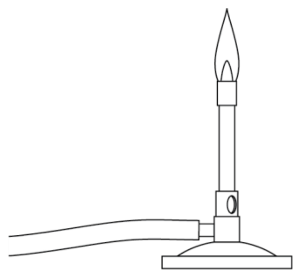
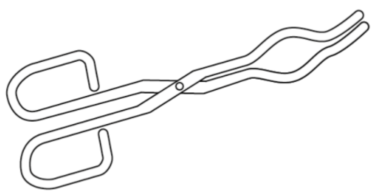
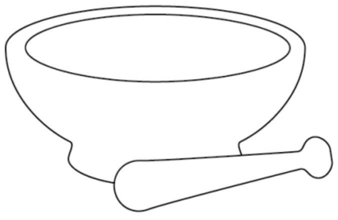
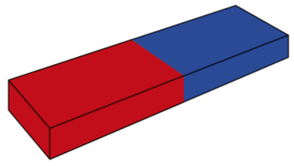
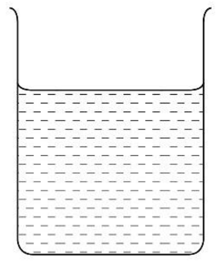
Cut along the horizontal strips and arrange the elements into a reactivity series with the most reactive element at the top.

Element	Reaction with water/steam	Reaction with air	Reaction with dilute acids

calcium	fast evolution of hydrogen gas	shiny calcium metal reacts quickly with air to form the oxide	violent reaction (should not be performed)
iron	reacts very slowly with steam	very slow reaction	reacts slowly
potassium	very vigorous reaction, catches fire and burns with a lilac coloured flame	freshly cut element, tarnishes rapidly	explosive reaction (should not be performed)
magnesium	slow reaction with cold water, but reacts rapidly with steam	freshly polished magnesium slowly becomes dull	rapid evolution of hydrogen gas
copper	no reaction	tarnishes slowly over many years	no reaction
zinc	no reaction with cold water, but reacts with slowly with steam	tarnishes slowly in air	moderately fast reaction
sodium	vigorous reaction	freshly cut sodium oxidises quickly to form the oxide	explosive reaction (should not be performed)

Worksheet B: Planning the extraction of iron experiment

Using **all** the equipment below, design an experiment for the microscale extraction of iron from iron(III) oxide.

			
iron(III) oxide (watch glass)	**a match**	**a heat-proof mat**	**Bunsen burner**
			
a pair of metal tongs	**a mortar and pestle**	**a magnet**	**a beaker of water**

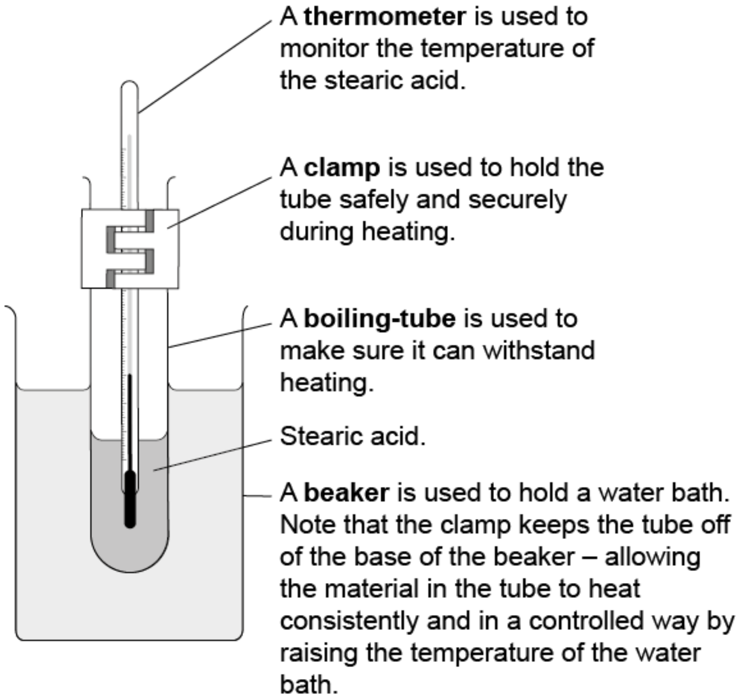
Worksheet B: Planning the extraction of iron experiment

In the space below, draw your experiment set-up.

Make sure you annotate your diagram showing the decisions you have made.

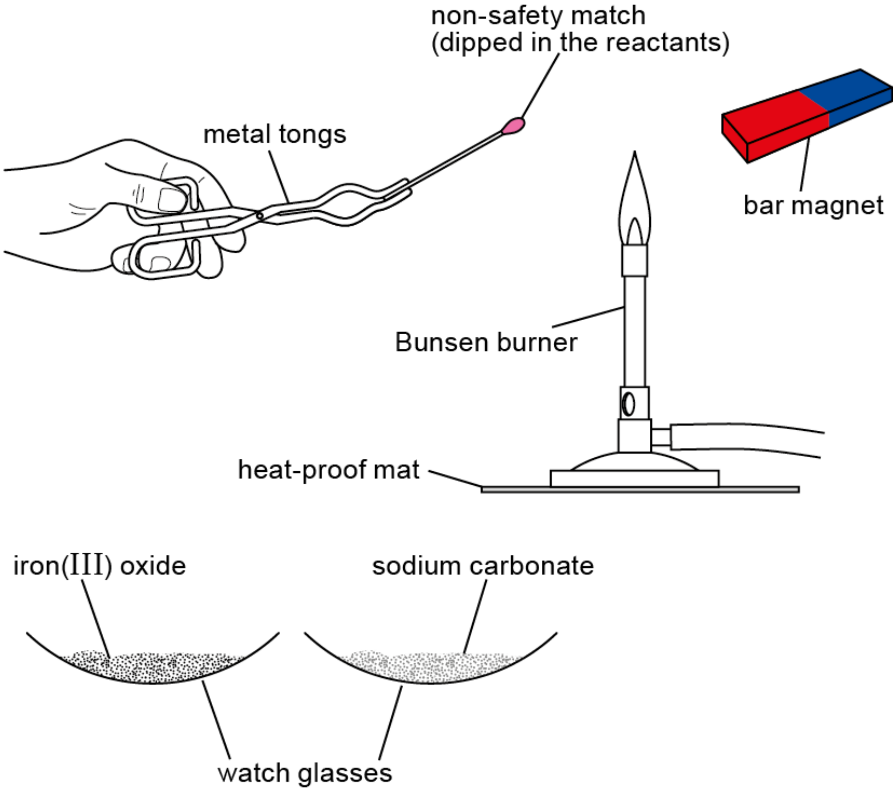
An example from a different experiment is shown

Example



Worksheet C: Experimental set-up and method

Experimental set-up



Method

1. Place small amounts of iron(III) oxide and sodium carbonate on to two separate watch glasses.

2. Take a magnet and move it underneath the watch glasses to check that the starting materials are non-magnetic.

Do not move the magnet above the watch glass, since any magnetic material will be attracted to the magnet and it will be very hard to remove.

3. Dip the match head in water and then roll it in the sodium carbonate, followed by the iron(III) oxide.

The sodium carbonate does not take part in the reaction, but it fuses easily and brings the carbon into close contact with the iron(III) oxide.

4. Hold the match in a pair of metal tongs and place the head of the match in a blue Bunsen burner flame.

Be careful not to burn yourself and make sure the heat-proof mat is in place.

5. Allow the match to burn half its length and then blow it out, allowing it to cool on the heat-proof mat.

Worksheet C: Experimental set-up and method

6. Carefully crush the match head with a spatula in a watch glass.

Do not apply too much pressure otherwise you might break the watch glass.

7. Take the magnet and move it under the watch glass to check if there is evidence that iron has been produced.

Again, do not move the magnet above the watch glass, since any magnetic material will be attracted to the magnet and it will be very hard to remove.

8. Record your results and evaluate your experiment using **Worksheet D**.

Worksheet D: Results and evaluation

1. **(a)** Was the iron(III) oxide and/or sodium carbonate attracted to the magnet at the beginning of the experiment?

……

(b) What does this suggest about these materials?

……

……

2. Where does the carbon come from in this reaction?

……

3. What caused the reaction to start?

……

4. What evidence was there for the production of iron in this experiment?

……

5. What other evidence did you observe of a chemical reaction in this experiment?

……

6. **(a)** Discuss any challenges involved in scaling up this method to produce useful amounts of iron?

……

……

Worksheet D: Results and evaluation

(b) Can you think of a way to produce iron on a larger scale?

You can draw a labelled diagram to support your answer.

……

……

……

……

……

……

Worksheet E: Chemical equation for the reaction

Answer the following questions which will help you construct the equation for the reaction and understand the process of oxidation and reduction.

1. (a) What are the reactants in this experiment?

……

(b) What are the products?

……

2. Write a word equation for the reaction.

……

3. Write a balanced chemical equation for the reaction.

……

4. Complete the following sentences for *oxidation* and *reduction*.

Oxidation is the ………………………… of oxygen.

Reduction is the ………………………… of oxygen.

Worksheet E: Chemical equation for the reaction

5. Refer to the balanced equation in question **3** and answer the following questions.

(a) Which substance has been reduced?

………

(b) What new substance formed through reduction?

………

(c) Which substance is the reducing agent?

………

(d) Which substance has been oxidised?

………

(e) What new substance formed through oxidation?

………

Worksheet F: Planning and using redox

PART A

A learner was provided with pea-sized pieces of haematite (iron(III) oxide) and powdered charcoal. She was given a free-choice of standard laboratory equipment to extract iron from its ore. She wrote the following method and tested it, but unfortunately it did not work.

i. Pieces of haematite (5 g) and powdered charcoal (5 g) were placed together in a glass beaker (100 cm^3).

ii. Water (30 cm^3) was added and the contents of the beaker were stirred using a glass rod.

iii. The mixture was boiled for 5 min and then allowed to cool.

iv. The contents of the beaker were filtered and washed with distilled water, leaving a dark residue.

v. The residue was dried and tested with a plastic –covered magnet to see if it contained iron.

Re-write the method in the space provided, so that the experiment will successfully produce iron.

Replace/add any standard laboratory equipment as required. Sodium carbonate or any additional chemicals are not needed. You may use as many steps as you wish.

Model answer:

………

………

………

………

………

………

Worksheet F: Planning and using redox

PART B

Answer the following questions about the equation for the production of iron.

$$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

Using **OILRIG**

1. (a) What is the reducing agent in the reaction? …………………….……………….………….……..

(b) What does it reduce? …………………………..…………..…………...

(c) Using **OILRIG**, show the change that occurs to the iron ions as a half-equation.

(d) Explain if the change in **(c)** above is an oxidation or reduction.

……

……

Using **OXIDATION STATES**

2. (a) Using oxidation states, explain how carbon has been oxidised.

$$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

(b) Why can't the OILRIG method be applied to explain this oxidation?

……

……

(c) Show that the iron ions have been oxidised using oxidation states.

$$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

……

Worksheet G: The extended reactivity series

potassium

sodium

calcium

magnesium

aluminium

carbon

zinc

iron

tin

lead

copper

silver

gold

platinum

Worksheet A: Answers

Element	Reaction with water/steam	Reaction with air	Reaction with dilute acids
potassium	very vigorous reaction, catches fire and burns with a lilac coloured flame	freshly cut element, tarnishes rapidly	explosive reaction (should not be performed)
sodium	vigorous reaction	freshly cut sodium oxidises quickly to form the oxide	explosive reaction (should not be performed)
calcium	fast evolution of hydrogen gas	shiny calcium metal reacts quickly with air to form the oxide	violent reaction (should not be performed)
magnesium	slow reaction with cold water, but reacts rapidly with steam	freshly polished magnesium slowly becomes dull	rapid evolution of hydrogen gas
zinc	no reaction with cold water, but reacts with slowly with steam	tarnishes slowly in air	moderately fast reaction
iron	reacts very slowly with steam	very slow reaction	reacts slowly
copper	no reaction	tarnishes slowly over many years	no reaction

Worksheet D: Answers

1. **(a)** *No*

(b) *They are non-magnetic materials.*

2. *It is produced from the burning of wood, as the match burns.*

3. *Striking the match causes the match to ignite (it is a complex reaction in itself). This exothermic reaction generated lots of heat which caused the reaction of carbon with iron(III) oxide to occur.*

4. *A magnetic material was produced. The iron followed the magnet around meaning it was attracted to it.*

5. *The red colour of the iron(III) oxide disappeared suggesting it had been used up in the reaction.*

6. **(a)** *To produce useful quantities of iron the match would have to be enormous (and this would be dangerous to perform also).*

(b) *The learners may have lots of different suggestions here.*

However, the general idea of intimately mixing carbon powder and iron(III) oxide together and heating strongly in a test-tube or other suitable vessel should gain credit and be discussed.

Worksheet E: Answers

1. **(a)** *Iron(III) oxide and carbon*

   (b) *iron and carbon dioxide*

2. *Iron(III) oxide* + *carbon* ⟶ *iron* + *carbon dioxide*

3. $2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$

4. Oxidation is the *addition* of oxygen.

   Reduction is the *removal* of oxygen.

5. **(a)** *iron(III) oxide has been reduced*

   (b) *iron metal*

   (c) *carbon*

   (d) *carbon has been oxidised*

   (e) *carbon dioxide*

Worksheet F: Answers

Part A

Model answer:

i. Pieces of haematite (5 g) were ground into a fine powder using a mortar and pestle.

ii. The powdered haematite and powdered charcoal (5 g) were mixed together thoroughly and placed in a metal crucible (or hard glass test-tube).

iii. The mixture was heated strongly using a Bunsen burner for 5 min.

iv. The contents of the crucible/tube, were allowed to cool.

v. A plastic-covered magnet was brought close to the mixture to see if it contained iron.

Part B

1. (a) carbon

(b) It reduces the iron(III) oxide

(c) $Fe^{3+}(s) \quad + \quad 3e^- \quad \rightarrow \quad Fe(s)$

(d) It is a reduction, because the iron ions have gained electrons to form elemental iron (OILRIG). We can say the iron ions have been reduced.

2. (a)

$$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

oxidation

oxidation state = 0 (C) — oxidation state = +4 (CO_2)

Carbon has been oxidised because its oxidation state has increased from 0 to 4.

Worksheet F: Answers

(b) This is because carbon dioxide is covalently bonded and therefore contains no ions. As a result, an ionic half-equation cannot be written.

(c)

$$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

reduction

oxidation state = +3

oxidation state = 0

The iron ions have been reduced because their oxidation state has decreased from +3 to 0.

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