Name

iG Chem 10 Topic Book 2020 Metal Reactivity, Extraction & Uses

Contents

A note on the textbook used

The textbook used is Essential Chemistry for iGCSE By R Norris, which maps closer to the syllabus than any other textbook I know and only includes what is needed for this syllabus. It's chapters are in the syllabus order, but Topic 10 has been split into 2 separate chapters, chapters 13 and 14, which are both contained in this topic book.

How to use this Topic Book

The topic has been broken down into sections based on the syllabus and the focus of the exam questions.

Each main idea within the section is described and explained in 2-page spreads.

Each 2-page spread ought to be completed in a systematic way: space is available in this topic book to do this. The process is based on the Cornell Notetaking system. (This process can be used for any subject BTW 😊).

Activity	What you should do	Why it helps	When you should do it
1. Translation	Translate **ALL** new words, especially the ones in **bold**, ideally next to the text. Use the glossary at the back to help you.	The most important words to translate are the non-scientific words you already know in Chinese.	As you are reading.
2. Underlining	Underline, highlight circle, put a *star or symbol 😉 next to the biggest new ideas. But remember, if you highlight everything, you've actually highlighted nothing ☹.	Completing the in the Key Points task becomes quicker but most importantly, it is a form of ACTIVE READING.	As you are reading.
3. Answers	Answer the Summary Questions about the material at the end of the double page spread.	Here you are shown what is most important about the ideas of this 2-page spread and forced to think about it in a new way.	After you have finished reading both pages
4. Checking Answers	Check your answers with the answers provided at the end of the booklet	Any major misunderstandings or confusions you have are likely to be discovered doing this.	After you've finished your answers
5. Key Points	Main ideas, equations and diagrams for both pages. It's the idea that you are trying to describe to your self, so try to make it as visual and colourful as possible! Make sure whatever you write is in your own words!!! Include any notes you have from lessons here!	At this point you are now starting to own the information you are processing. This task will force your brain to think about what is most important because space is limited and writing is work. After you have thought about it in a new way, you'll need to remember your thoughts long enough to write them out, helping your long-term memory. This will also help to write out better que questions.	After you have finished the going through the questions and answers, but before you start the next two pages.
6. Cue Questions v1.0	Write out, in your own words, questions and bullet points that will force you to think about the essential ideas. Links to other parts of the topic and syllabus should also be included (e.g. half-equations are also covered in Topic 5 (Electrochemistry), so a note like: **T5** $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ **[conc only!]** Might be a good idea if you've missed a mark on this before.	If you covered up the notes section of the page, answering these questions should allow you revise the whole page simply by answering a few questions and thinking about a few core ideas. If this is done carefully and thoughtfully not only will it make revision quicker later on, but also because it helps long term memories form, it'll mean less revision is needed to get the highest grade.	After you've finished the next 2-page spread.
7. Summary	Write one or two sentences, in your own words that contain only the most important ideas.	Another way of thinking about it is: what's the least useful or important 80% content here? Give a thoughtful person 2 tasks and the first thing they'll do is create a third task which they'll do first and prioritize which of the two is most important.	After you've finished the section
8. Cue Questions v2.0	Write out, in a different colout, or in any other way to identify it, any new questions or details that you've discovered are important to getting full marks on questions assessing material covered in this 2 page spread. After you've worked on the past exam questions you should understand this section as well as the quality of the work	The tricky marks and the slippery explanations (especially that 2nd or 3rd mark) are most obvious now, but unless you make a decent effort to write them down, not only will you have lost the value of the work you have done because you'll be less likely to remember them, you'll also have no record to use later on. This is	After you've finished the past exam questions

Activity	What you should do	Why it helps	When you should do it
	you have put in deserves. You should also know in detail which marks are the hardest and this information needs to go into your Cue section so the work you've put in to discover this information isn't abandoned or forgotten.	essentially saving your hard work for later when you'll nee it most.	
9. Top tips	Any new tough mark or detail that you have overlooked.	This level of attention to detail will help you become a person who is far less likely to make a mistake, but if you do, is far more likely to learn from it. It's your capacity to learn effectively and efficiently that will get you into a good university in the short term; in the long term it will allow you to do more interesting things with your work and your life.	Any time after you've finished the topic, but before the iGCSE exam

After you have finished reading and making notes from each section you should create a mind map, ideally from memory. Then go through the textbook section again and look for parts you have missed out, which should be added in a different colour, or some other way for you to later identify these more challenging parts. With good notetaking these difficult sections will produce from you notes that will allow you to revise much quicker later on before the end of topic test and later exams.

How to use the 2 past exam question booklets (Paper 3 and Paper 2) with this topic book

After completing each section of the textbook work through the past exam questions section which will allow you to find out how well you have understood the material.

The revision booklet will include more recent questions and should also be used if you have not already finished it.

After you have completed the past exam questions you should produce a final mind map that emphasises the main ideas that you struggled with most. This mind map may only include only a very limited information on the easiest parts of the syllabus, focusing instead on your explanations to yourself about what you have learnt is expected from the most difficult questions about this topic.

For the Past Exam Questions from Paper 3 you need to answer questions on pages 1 to 18 for the first section (Section 10.1 & 10.2 Metals and Reactivity).

For the Past Exam Questions from Paper 3 you need to answer questions on pages 18 to 44 for the second section (Section 10.3 & 10.4 Metal Extraction and Uses).

You do not need to do all of the questions from each subtopic, but you should do a balanced amount from each subtopic if you are not intending on finishing the whole Paper 3 Topic 10 booklet.

After you have finished the Paper 3 questions, or done as many as you can, you can work through the multiple choice questions from Paper 2. These are not broken down by subtopic, so you can simply do as many as possible in any order.

How to print this booklet

If you print this booklet as A4 double sided and staple down the left hand side each 2-page spread will be in the right place. If double sided printing is difficult, then simply print single sided, which will work just as well.

Syllabus Details

10 Metals

10.1 Properties of metals

Core

- List the general physical properties of metals
- Describe the general chemical properties of metals, e.g. reaction with dilute acids and reaction with oxygen
- Explain in terms of their properties why alloys are used instead of pure metals
- Identify representations of alloys from diagrams of structure

10.2 Reactivity series

Core

- Place in order of reactivity: potassium, sodium, calcium, magnesium, zinc, iron, (hydrogen) and copper, by reference to the reactions, if any, of the metals with:
  - water or steam
  - dilute hydrochloric acid

  and the reduction of their oxides with carbon
- Deduce an order of reactivity from a given set of experimental results

Supplement

- Describe the reactivity series as related to the tendency of a metal to form its positive ion, illustrated by its reaction, if any, with:
  - the aqueous ions
  - the oxides

  of the other listed metals
- Describe and explain the action of heat on the hydroxides, carbonates and nitrates of the listed metals
- Account for the apparent unreactivity of aluminium in terms of the oxide layer which adheres to the metal

10.3 Extraction of metals

Core

- Describe the ease in obtaining metals from their ores by relating the elements to the reactivity series
- Describe and state the essential reactions in the extraction of iron from hematite
- Describe the conversion of iron into steel using basic oxides and oxygen
- Know that aluminium is extracted from the ore bauxite by electrolysis
- Discuss the advantages and disadvantages of recycling metals, limited to iron/steel and aluminium

Supplement

- Describe in outline, the extraction of zinc from zinc blende
- Describe in outline, the extraction of aluminium from bauxite including the role of cryolite and the reactions at the electrodes

10.4 Uses of metals

Core

- Name the uses of aluminium:
  - in the manufacture of aircraft because of its strength and low density
  - in food containers because of its resistance to corrosion
- Name the uses of copper related to its properties (electrical wiring and in cooking utensils)
- Name the uses of mild steel (car bodies and machinery) and stainless steel (chemical plant and cutlery)

Supplement

- Explain the uses of zinc for galvanising and for making brass
- Describe the idea of changing the properties of iron by the controlled use of additives to form steel alloys

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

Section 10.1&2 Metals and Reactivity

13.1 Alloys

LEARNING OUTCOMES

- Describe the general physical and chemical properties of metals
- Explain why metals are often used in the form of alloys
- Identify representations of alloys from diagrams of their structure

In Unit 2.5 we learnt that metals are:

- good conductors of electricity and heat
- malleable – they can be hammered into different shapes
- ductile – they can be drawn into wires
- shiny.

A metal such as iron is rarely used on its own because it rusts easily. Pure copper is not very strong so cannot be used for parts of machines that are constantly in motion. We can change the properties of a metal to make it harder or more resistant to corrosion. We do this by mixing it with another metal or with a non-metal.

A mixture of two or more metals, or one or more metals with a non-metal, is called an **alloy**. An alloy is not just a mixture of metal crystals. The atoms of the second metal form part of the crystal lattice.

EXAMINER SAYS...

It is a common error to think that all metals are hard and have very high melting points. Remember that Group 1 metals are soft and have low melting points.

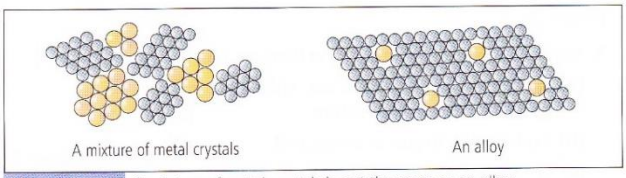


Figure 13.1.1 A mixture of metal crystals is not the same as an alloy.

PRACTICAL

Tin, lead and solder

Solder is an alloy of lead and tin. It is used to join wires in electrical circuits. You put small pieces of tin, lead and solder on the steel 'tin' lid and heat the centre. You record the time taken for each metal to melt. The solder melts long before the tin and lead. This shows that the alloy has different properties from the tin and lead alone.

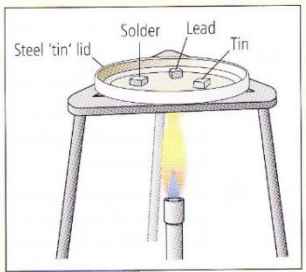


Figure 13.1.2

Explaining the difference

The atoms in a pure metal are arranged in regular layers. When a force is applied, the layers slide over each other. This explains why metals are malleable and ductile. When a metal is alloyed with a second metal, the different sized metal atoms make the arrangement of the lattice less regular. We say that they disrupt the crystal lattice. This stops the layers

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

For a whole variety of different formats and types of paper: https://incompetech.com/graphpaper/cornelllined/

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

of metal atoms sliding easily over each other when a force is applied. This is why an alloy is stronger and harder than a pure metal.

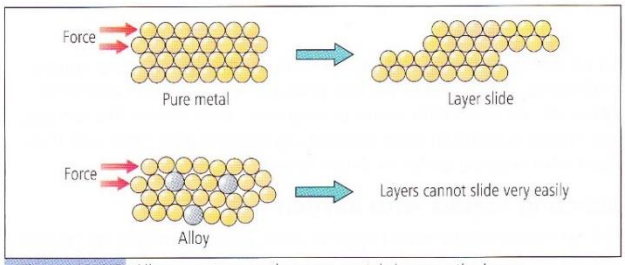


Figure 13.1.3 Alloys are stronger than pure metals because the layers cannot slide easily.

Uses of alloys

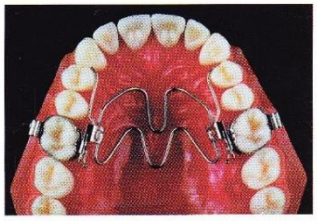
Alloys have many uses. Some of these are given in the table.

alloy	properties	uses
brass (copper + zinc)	stronger than copper but still malleable	musical instruments, ornaments
bronze (copper + tin)	very hard	some moving parts of machines, statues, bells
stainless steel (iron + chromium + nickel)	does not rust like iron	car parts, cutlery, parts of chemical factories, surgical instruments

In recent years a number of alloys with 'memory' properties have been made. One of these, an alloy of nickel and titanium is called 'nitinol'. If a piece of nitinol wire is manufactured in an 'S' shape it remembers that shape. If you straighten it out, it stays straight. But when it is put into some hot water it changes back to its 'S' shape. These alloys are called 'shape memory alloys'. They are useful for making spectacle frames and dental braces.

DID YOU KNOW?

'Smart' alloys are able to 'remember' their shape. Springs made from these alloys 'remember' to open out at about 90°C but close up again when cooled. They can be used to activate fire sprinklers.



'Smart' alloys are used in some dental braces. As the alloy warms up, it pulls the teeth into the correct position.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

alloy mixture layers non-metal slide stronger

An alloy is a _____ of metals or a mixture of metals with a _____. By making a metal into an _____ it becomes _____ and harder. This is because the _____ of metal atoms in the alloy cannot _____ over one another very easily.

2 Explain why an alloy of aluminium and manganese is stronger than pure aluminium.

3 Draw a diagram to show the arrangement of the atoms in:

a a pure metal

b an alloy.

KEY POINTS

1 Alloys are mixtures of metal atoms with other metal atoms or non-metal atoms.

2 The properties of a metal are changed by making it into an alloy.

3 Metals are made into alloys to improve their strength, hardness or resistance to corrosion.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

13.2 The Metal Reactivity Series

LEARNING OUTCOMES

- Place metals in a reactivity series by referring to their reactions with water, steam and hydrochloric acid
- Deduce an order of reactivity from information given

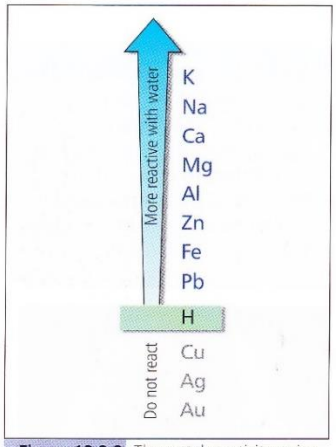


Figure 13.2.2 The metal reactivity series.

DID YOU KNOW?

An isotope of caesium, a very reactive metal, is used in atomic clocks to measure time with great accuracy.

Activities To Do

(complete as you are reading)

A1. Translating

A2. Underlining

A5. Key Points
(in space below)

Some metals are very reactive. The Group I meals react very rapidly with water. Other metals are less reactive. The transition elements either do not react with water or only react with steam. We can put the metals in order of their reactivity by investigating how well they react with oxygen, water or dilute hydrochloric acid.

Reacting metals with oxygen

The list below shows what happens when different metals are heated in air. The metals react with the oxygen in the air to form metal oxides.

- **copper**: does not burn but turns black on its surface
- **iron**: only burns when in powder form or as iron wool
- **gold**: does not burn at all, even as a powder
- **magnesium**: burns rapidly with a bright white light

From this list of reactions we can put these metals in order of reactivity:

magnesium (most reactive) → iron → copper → gold (least reactive)

Reacting metals with water or steam

If a metal does not react with cold water it may react with steam.

DEMONSTRATION

Reacting iron wool with steam

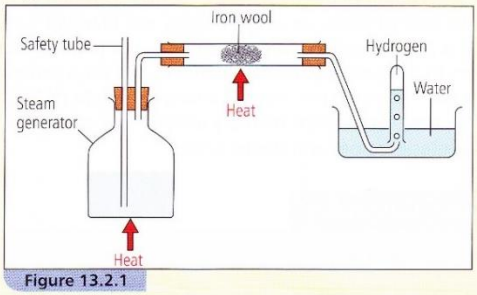


Figure 13.2.1

We pass steam over red-hot iron wool. The iron turns black. We collect the gas in a test tube. The gas pops with a lighted splint. The iron has reacted and formed iron oxide and hydrogen.

The table shows how different metals react with water or steam.

calcium	reacts rapidly with cold water
copper	no reaction with cold water or steam
magnesium	reacts very slowly with cold water but reacts rapidly with steam
sodium	react violently with cold water
zinc	only reacts when powdered and heated strongly in steam

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

From the information in the table we can put these metals in order of their reactivity:

sodium calcium magnesium zinc copper

most reactive → least reactive

If a metal reacts with cold water, a metal hydroxide and hydrogen are formed:

$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$

calcium + water → calcium hydroxide + hydrogen

If a metal only reacts with steam, a metal oxide is formed:

$3Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)$

iron + steam → iron oxide + hydrogen

EXAMINER SAYS...

Remember that metals that react with cold water form metal hydroxides. When a metal is heated in steam, an oxide is formed.

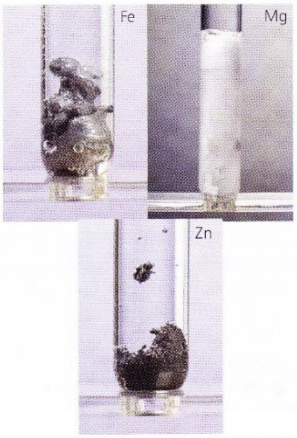
Reaction with dilute acid

The table shows how different metals react with dilute hydrochloric acid.

sodium	very violent – explosive	most reactive ↑
calcium	very rapid – lots of hydrogen bubbles produced	
magnesium	rapid – bubbles of hydrogen produced steadily	
zinc	slow – bubbles of hydrogen produced slowly	
copper	no reaction with dilute or concentrated acid	least reactive

The metal reactivity series

We can use the reactions of elements with oxygen, water and hydrochloric acid to build up part of the **reactivity series**. By reacting metals with different solutions of metals ions we can extend this reactivity series. If you look at the reactivity series shown opposite you will notice that we have included hydrogen in the reactivity series. Metals below hydrogen do not react with cold water or steam. They do not release hydrogen from hydrochloric acid either. So copper, silver and gold are very unreactive.



We can put magnesium, zinc and iron in order of reactivity by comparing how rapidly they react with an acid: 1. Mg, 2. Zn, 3. Fe.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

cold hydrogen hydroxide iron potassium steam

Sodium, _____ and calcium react with _____ water to form a metal _____ and hydrogen. Less reactive meals such as _____ and zinc do not react with cold water but they do react with _____. Metals below _____ in the reactivity series do not react with water or steam.

2 Platinum is never found in nature combined with oxygen. What does this tell you about the reactivity of platinum?

3 Tin is between iron and lead in the reactivity series. Suggest how tin will react with:
a cold water b steam.

KEY POINTS

1 Metals can be arranged in a reactivity series by comparing how easily they react with water, steam and hydrochloric acid.

2 Only metals above hydrogen in the reactivity series react with hydrochloric acid.

3 Only metals above hydrogen in the reactivity series will react with water or steam.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

13.3 More about metal reactivity

Extension

LEARNING OUTCOMES

- Place metals in a reactivity series by referring to the reaction between metals and metal ions
- Explain the reactivity of metals in terms of the ease of formation of metal ions

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

DID YOU KNOW?

When a small piece of sodium reacts with water about 100 000 000 000 000 000 sodium atoms change to sodium ions every second!

EXAMINER SAYS...

In your exam you will usually be given the reactivity series to help you answer questions about the ease of formation of ions.

In Unit 12.3 we saw that a more reactive halogen will replace a less reactive halogen in a metal halide. We can think of this as a competition to see which halogen combines the best with the metal. We call this type of redox reaction a **displacement** reaction. Can metals compete in a similar way?

DEMONSTRATION

The 'thermit' reaction

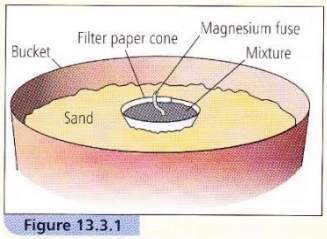


Figure 13.3.1

We put a mixture of aluminium powder and iron(III) oxide into a cone of filter paper. This is placed in a bucket of sand. We light the magnesium fuse. A vigorous reaction occurs with flames, light and smoke. We find a lump of iron where the mixture was.

In the 'thermit' reaction the aluminium displaces the iron from the iron(III) oxide:

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3$$

iron(III) oxide + aluminium → iron + aluminium oxide

We can carry out similar experiments using metals and solutions of metal ions. When we add excess zinc to a solution of copper(II) sulfate, the zinc gets coated with copper and the solution turns colourless.

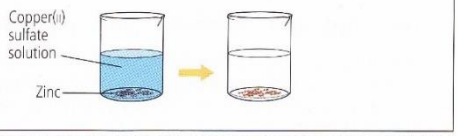


Figure 13.3.2 The more reactive metal, zinc, displaces the less reactive copper from copper(II) sulfate solution.

Zinc is higher in the reactivity series than copper. So it displaces copper from the copper(II) sulfate solution. The solution turns colourless because colourless zinc sulfate is formed:

$$Zn(s) + CuSO_4(aq) \longrightarrow ZnSO_4(aq) + Cu(s)$$

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

Extension

By carrying out experiments using different combinations of metals and solutions of metal salts, we can arrange all the metals in a metal reactivity series. A more reactive metal will displace a less reactive metal from a solution of its salt. We sometimes call this reactivity series the electrochemical series.

Because these are redox reactions, we can write half equations for oxidation and reduction. For example:

oxidation of zinc to zinc ions:

$$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$$

reduction of copper ions to copper:

$$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$$

Explaining reactivity

In the half reactions above, we can see that each atom of the more reactive metal loses electrons and each ion of the less reactive metal gains electrons. The more reactive a metal is, the more easily it loses its valency electrons. It is easier to lose electrons from the outer (valency) shell if:

- the valency electrons are further away from the pull of the nucleus. Remember that negative electrons are attracted to positive protons.
- there are more electron shells between the nucleus and the valency electrons. These shells shield the valency electrons from the charge of the nucleus.
- there are fewer protons in the nucleus (less nuclear charge) to pull the electrons towards them.

Potassium is more reactive than sodium because its valency electrons are further from the nucleus and there are more shells between the valency electrons and the nucleus. This outweighs the effect of the increased number of protons in the nucleus of potassium. So potassium can lose its valency electron more easily than can sodium.

Magnesium is less reactive than sodium because even though the valency electrons are in the same shell magnesium has a greater nuclear charge. So magnesium will not lose its valency electrons as easily as sodium.

The copper has reacted with silver nitrate and crystals of silver have formed on its surface.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

displaces **less** **more** **solution** **valency**

A more reactive metal _____ a _____ reactive metal from a _____ of its salt. This is because the _____ reactive metal loses its _____ electrons more easily.

2 Silver is less reactive than copper but copper is less reactive than magnesium. Write symbol equations for:
- a the reaction of copper(II) sulfate with magnesium
- b the reaction of silver nitrate with copper.

3 Explain why copper will not react with iron(II) sulfate.

KEY POINTS

1 A more reactive metal displaces a less reactive metal from a solution of its salt.

2 A more reactive metal loses its valency electrons more easily than a less reactive metal.

3 The ease with which a metal loses its valency electrons to form ions depends on the distance of the valency electrons from the nucleus, the nuclear charge and the number of electrons shells.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

13.4 From metal oxides to metals

LEARNING OUTCOMES

- Describe the use of carbon as a reducing agent for some metal oxides

Extension

- Explain the use of carbon as a reducing agent
- Explain the apparent unreactivity of aluminium

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

Competing for oxygen

When you heat powdered iron with copper(II) oxide, CuO, the iron displaces the copper:

$$Fe(s) + CuO(s) \xrightarrow{heat} FeO(s) + Cu(s)$$

The iron competes better to 'hold onto' the oxygen. This is because iron is higher in the reactivity series than copper. The iron is oxidised to iron(II) oxide and the copper(II) oxide is reduced to copper. The more reactive metal, in this case iron, is the reductant. It removes the oxygen from the less reactive metal's oxide.

Reducing metal oxides with carbon

We can also carry out reduction using carbon as a reductant (reducing agent). For example: Carbon is more reactive than copper. So carbon removes the oxygen from copper(II) oxide when heated.

$$2CuO(s) + C(s) \xrightarrow{heat} 2Cu(s) + CO_2(g)$$

copper(II) oxide + carbon → copper + carbon dioxide

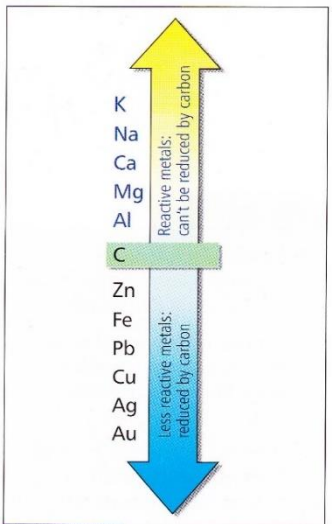


Figure 13.4.2 Metals below carbon in the reactivity series can be extracted by heating with carbon. Metals above carbon are extracted by electrolysis.

PRACTICAL

Reducing copper(II) oxide with carbon

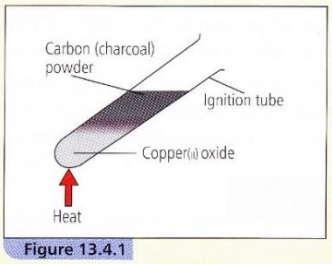


Figure 13.4.1

You put a layer of charcoal powder (carbon) over a layer of copper(II) oxide then heat the tube srongly. When the reaction is over you can see some pinkish-brown copper metal where the two layers of powder meet.

So which metals can carbon reduce? Look at the position of carbon in the reactivity series. Only the oxides of the metals below carbon can be reduced to the metal by heating with carbon. Metals more reactive than carbon have to be extracted by electrolysis.

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

Extension

Explaining the use of reductants

We can explain the use of reactive metals and carbon to reduce metal oxides in terms of movement of electrons. A more reactive metal loses its electrons and combines with oxygen more easily than a less reactive metal. So a more reactive metal will be able to remove the oxygen from the oxide of a less reactive metal. The more reactive metal is a better reductant.

If a metal is below carbon in the reactivity series the oxygen in its oxide will form covalent bonds more easily with carbon than with the metal. The carbon is then the reductant.

Why does aluminium seem unreactive?

Aluminium is high in the reactivity series but it does not seem to react with water or acids. It will only react with acids when it is freshly made. This is because, when the surface of freshly made aluminium is left in the air, a thin layer of aluminium oxide quickly forms on its surface:

$$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$$

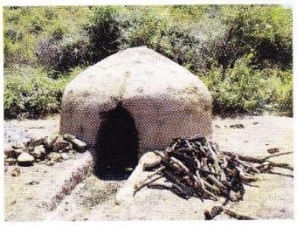
This layer is only about 0.0002 cm thick, but this is enough to make the metal resistant to corrosion. The tough oxide layer sticks to the surface of the aluminium very strongly and does not flake off. The oxide layer is unreactive.

DID YOU KNOW?

The earliest evidence for the extraction of lead comes from Turkey. Beads of lead have been found that are thought to have been extracted 8500 years ago.

EXAMINER SAYS...

Remember that aluminium is a reactive metal. It must be reactive if it forms an unreactive oxide layer on its surface so quickly.



Charcoal kilns like these have been used for centuries to provide the carbon for metal extraction.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

below heated metals oxygen reduced reductant

Metal oxides _____ carbon in the reactivity series are _____ to _____ when they are _____ with carbon. In this reaction carbon is the _____ because it removes the _____ from the metal oxide.

2 Write balanced equations for:

a the reaction of zinc oxide, ZnO, with carbon to form zinc and carbon dioxide

b the reaction of magnesium with copper(II) oxide to form magnesium oxide and copper.

Extension

3 Explain why freshly made aluminium reacts with hydrochloric acid but old aluminium does not react.

KEY POINTS

1 Metal oxides below carbon in the reactivity series are reduced by carbon when heated.

2 When a more reactive metal is heated with the oxide of a less reactive metal, the more reactive metal acts as a reductant.

3 The apparent lack of reactivity of aluminium is due to an unreactive oxide layer that forms on its surface. Extension

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

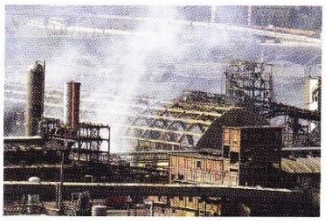
A6 (&A8). Cue questions
Fill this in AFTER finishing the section

13.5 Thermal decomposition

Extension

LEARNING OUTCOMES

- Describe the action of heat on selected hydroxides and nitrates
- Link the thermal decomposition of nitrates to the reactivity of the metals



Nitrates can decompose explosively to cause a large amount of damage, as shown by the remains of this fertiliser factory.

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

EXAMINER SAYS...

You need to remember the products from the thermal decomposition of nitrates. If you don't know these, you won't be able to write equations for thermal decomposition.

When we heat some carbonates, nitrates and hydroxides, they break down to form two or more different products. We call this type of reaction **thermal decomposition**. For example, the equation:

$$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$$

represents the thermal decomposition of calcium carbonate.

Thermal decomposition of metal hydroxides

Most metal hydroxides decompose when heated. A metal oxide and water are formed. For example:

$$Zn(OH)_2(s) \xrightarrow{heat} ZnO(s) + H_2O(g)$$

zinc hydroxide → zinc oxide + water

All Group II hydroxides decompose in a similar way. Most alkali metal hydroxides, however, do not decompose. They are stable to heat. There is one exception to this: lithium hydroxide.

$$2LiOH(s) \xrightarrow{heat} Li_2O(s) + H_2O(g)$$

lithium hydroxide → lithium oxide + water

Lithium is the least reactive of the alkali metals. So does thermal decomposition depend on the reactivity of the metal? We shall look at the decomposition of nitrates and carbonates to answer this question.

Thermal decomposition of nitrates

All nitrates decompose when heated. But there are some differences in how they decompose. The alkali metal nitrates decompose to form a ***nitrite*** and oxygen. You can see that the nitrite ion is similar to the nitrate ion but has one fewer oxygen atom:

$$2KNO_3(s) \xrightarrow{heat} 2KNO_2(s) + O_2(g)$$

potassium nitrate → potassium nitrite + oxygen

Nitrates of other metals decompose on heating to form an oxide, nitrogen dioxide and oxygen. For example:

$$2Mg(NO_3)_2(s) \xrightarrow{heat} 2MgO(s) + 4NO_2(g) + O_2(g)$$

magnesium nitrate → magnesium oxide + nitrogen dioxide + oxygen

Lithium nitrate, a compound of the least reactive alkali metal, decomposes in this way too.

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

Extension

Nitrates of very unreactive metals, such as silver, decompose to form the metal when they are heated:

$$2AgNO_3(s) \xrightarrow{\text{heat}} 2Ag(s) + 2NO_2(s) + O_2(g)$$

silver nitrate → silver + nitrogen dioxide + oxygen

DEMONSTRATION

The decomposition of Group II nitrates

This experiment is demonstrated using a fume cupboard because nitrogen dioxide is poisonous.

We start a stopclock when we begin to heat the magnesium nitrate. The nitrate is heated until we see dark brown fumes of nitrogen dioxide in the tube. We record the time taken to see these fumes. Then we repeat the experiment using other nitrates. In this experiment we must keep the amount of nitrate and the rate of heating the same.

The longer it takes for the nitrate to decompose, the more stable the nitrate is.

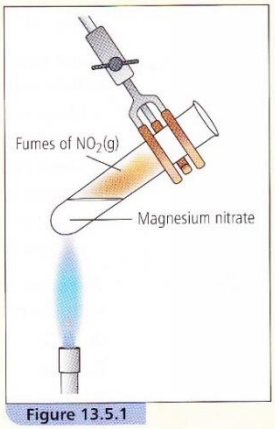


Figure 13.5.1

Magnesium nitrate decomposes at 402 °C but barium nitrate decomposes at 865 °C. So it appears that barium nitrate is more stable than magnesium nitrate. Barium is more reactive than magnesium. So the more reactive the metal, the more stable to thermal decomposition its compound is. This is well demonstrated if we look at the temperatures at which carbonates decompose when heated.

Thermal decomposition of carbonates

The table shows the temperatures at which the Group II carbonates decompose.

Group II carbonate	magnesium carbonate	calcium carbonate	strontium carbonate	barium carbonate
decomposition temperature/°C	540	900	1280	1360

The reactivity of the Group II metals increases down the group. You can see from the table that as you go down the group it gets more difficult to decompose the carbonates. So the more reactive the metal, the more stable its nitrate, carbonate or hydroxide is.

KEY POINTS

1 Thermal decomposition is the breakdown of a compound into two or more different products by heat.
2 The more reactive the metal, the more stable its nitrate, hydroxide or carbonate.
3 Metal hydroxides decompose to oxides and water when heated.
4 Most nitrates decompose to either nitrites and oxygen or to oxides, nitrogen dioxide and oxygen when heated.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

alkali dioxide heated less nitrite oxygen

Nitrates of the _____ metals decompose when _____ to form the metal _____ and oxygen. Nitrates of _____ reactive metals form metal oxides, nitrogen _____ and _____ when heated.

2 Write equations for the thermal decomposition of:
- a copper(II) hydroxide, $Cu(OH)_2$
- b calcium nitrate, $Ca(NO_3)_2$.

3 Suggest why lithium nitrate decomposes in a similar way to a Group II nitrate rather than a Group I nitrate.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

Mind Map 1 of Section 10.1 & 10.2

(Chapter 13) Summary & Exam Questions for Sections 10.1 & 10.2

These questions can be looked at, but they have limited use if you are working towards an A*, they could be attempted under test-like conditions and used as a revision exercise, for instance

SUMMARY QUESTIONS

1 Copy and complete using the words from the list below.

alkali hydroxides iron oxide oxygen potassium powder sodium water

Metals can be put in order of reactivity using their reactivity with _____ as a guide. Alkali metals such as _____ and _____ react rapidly with water as well as _____. The _____ metals react with cold water to form alkali metal _____. Less reactive metals such as _____ will only react with oxygen if they are in wire or _____ form. Iron reacts with steam to form iron _____.

2 Use the following reactivity series to answer the questions below.

calcium magnesium zinc iron lead copper

most reactive ⟶ *least reactive*

(a) Which metals in the list will react with dilute hydrochloric acid?

(b) Which metals in the list will react with cold water?

(c) Which metals in the list will react with steam?

(d) Where would **(i)** potassium and **(ii)** silver come in this list?

3 Match the metals on the left with the phrases on the right.

sodium	a reactive metal that burns with a bright light to form a metal oxide
copper	a metal that reacts with water to form an alkaline solution
iron	a grey, fairly unreactive metal
lead	a pinkish-brown metal that is unreactive
magnesium	a metal that reacts with steam but not with cold water

Extension

4 Describe how the reactivity series depends on the ease with which a metal forms a positive ion.

5 Aluminium is a metal high in the reactivity series. Explain why aluminium apparently does not react with dilute hydrochloric acid.

EXAM-STYLE QUESTIONS

1 Lead reacts with carbon when heated:

$PbO + C \longrightarrow Pb + CO$

Which statement about this reaction is true?

A Lead(II) oxide is a reducing agent.

B Carbon is a reducing agent.

C Carbon is an oxidising agent.

D Carbon is reduced to carbon monoxide.

(Paper 1) [1]

2 Some information about the reaction of three metals with hydrochloric acid is given below.

- Metal P: dissolves slowly and a few bubbles are formed.
- Metal Q: dissolves rapidly and bubbles are formed very rapidly.
- Metal R: dissolves rapidly and bubbles are formed rapidly.

The order of reactivity of these metals, starting with the most reactive, is:

A PQR

B RQP

C QRP

D PRQ

(Paper 1) [1]

3 Some of the elements in the reactivity series are shown below:

sodium calcium magnesium zinc iron lead copper

most reactive ⟶ *least reactive*

(a) Which of these elements will react with cold water. [1]

6 Write symbol equations for:

(a) the reaction of magnesium with oxygen

(b) the reaction of iron with steam

(c) the thermal decomposition of calcium hydroxide

(d) the thermal decomposition of magnesium nitrate

(e) the reaction of iron(III) oxide, Fe_2O_3, with magnesium.

7 What do you understand by the term *thermal decomposition*?

A6 (&A8). Cue questions *Fill this in AFTER finishing the section*	***Answers to summary and Exam Questions*** *– Remember to check them AFTERWARDS and make notes on anything difficult or that you missed*

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

(b) Iron reacts with steam to form iron(III) oxide.

(i) Name one other element in the list that reacts with steam but does not react with cold water.

(ii) Copy and balance the following equation:

$$\_\_ Fe + \_\_ H_2O \longrightarrow Fe_3O_4 + \_\_ H_2$$

[3]

(c) Magnesium reacts with hydrochloric acid. Magnesium chloride and hydrogen are formed.

(i) Write a word equation for this reaction. *[1]*

(ii) Write a symbol equation for this reaction. *[2]*

(iii) How can you test for the hydrogen given off in this reaction? *[2]*

(d) Magnesium reacts with black copper(II) oxide when heated.

(i) Describe what you observe during this reaction. *[2]*

(ii) Write a word equation for this reaction. *[1]*

(iii) Which reactant is the reducing agent in this reaction? *[1]*

(Paper 2)

4 Brass is an alloy of zinc and copper.

(a) What do you understand by the term *alloy*? *[1]*

(b) Zinc is more reactive than copper.

(i) State two observations that you can make when zinc reacts with aqueous copper(II) sulfate. *[2]*

(ii) Write a word equation for this reaction. *[1]*

(iii) What type of chemical reaction is this? *[1]*

(c) Zinc reacts with steam but not with cold water. Potassium reacts with cold water.

(i) Explain why zinc does not react with cold water but potassium does. *[1]*

(ii) Copy and balance the equation for the reaction of potassium with water:

$$\_\_K + \_\_\_ H_2O \longrightarrow \_\_\_\_ KOH + H_2$$

[2]

(Paper 2)

5 Zinc powder reacts with copper(II) oxide on heating:

$$Zn + CuO \longrightarrow ZnO + Cu$$

(a) Which is the reductant in this reaction? Explain your answer. *[2]*

(b) Describe how electrons are transferred in this reaction. *[2]*

(c) Explain why the reverse reaction does not occur. *[1]*

(d) Both magnesium and lead are above copper in the reactivity series. Explain, in terms of ease of formation of ions, why magnesium is able to remove oxygen from copper oxide more readily than lead. *[2]*

(e) Copper(II) nitrate, $Cu(NO_3)_2$, decomposes in a similar way to magnesium nitrate. Write a balanced equation for the thermal decomposition of copper(II) nitrate, including state symbols. *[3]*

(Paper 3)

6 Sodium and magnesium are both reactive metals.

(a) (i) Describe the differences between the reactions of sodium and magnesium with water. *[2]*

(ii) Write a balanced equation to show the reaction of magnesium with steam. Include state symbols. *[3]*

(b) Sodium nitrate and magnesium nitrate behave differently on thermal decomposition.

(i) What do you understand by the term *thermal decomposition*? *[1]*

(ii) Write a balanced equation to show the thermal decomposition of sodium nitrate. *[2]*

(iii) Write a word equation for the thermal decomposition of magnesium nitrate. *[2]*

(c) Magnesium is more reactive than aluminium.

(i) Describe how you could use magnesium to extract aluminium from molten aluminium oxide. *[1]*

(ii) Suggest why this method not used to extract aluminium industrially. *[1]*

(iii) Explain why aluminium containers can be used to store acidic foods even though it is a reactive metal. *[2]*

(Paper 3)

A6 (&A8). Cue questions *Fill this in AFTER finishing the section*	***Answers to summary and Exam Questions*** *– Remember to check them AFTERWARDS and make notes on anything difficult or that you missed*

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

Mind Map 2 of Section 10.1 & 10.2

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

Section 10.3 &4 Metal Extraction & Uses

14.1 Metals from their ores

LEARNING OUTCOMES

- Describe bauxite as an ore of aluminium
- Describe how the ease of obtaining metals from their ores depends on the position of the metal in the reactivity series

Extension

- Describe the extraction of zinc from zinc blende

DID YOU KNOW?

About 30% of the pure zinc produced in the world comes from recycling the metal.

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

EXAMINER SAYS...

Extension

You will not be asked to draw the furnace used for the extraction of zinc but you should be prepared to label a diagram and write relevant equations.

Most metals found in the Earth's crust are present as compounds in the rocks. A rock from which a metal can be extracted is called an **ore**. Most ores are oxides or sulfides. Some important ores are **haematite** (iron ore), **bauxite** (aluminium ore) and **zinc blende** (zinc ore).

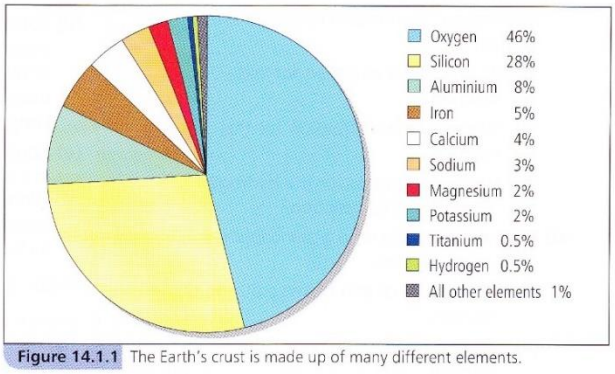


Figure 14.1.1 The Earth's crust is made up of many different elements.

Metal extraction and the reactivity series

The way we extract a metal from its ore depends on the position of the metal in the **reactivity series**. Carbon is used to reduce oxides of metals below it in the reactivity series. For example: oxides of zinc, lead and iron can be reduced by carbon. The carbon is usually used in the form of coke. This is coal from which some impurities have been removed.

$$\underset{\text{lead(II) oxide}}{PbO(s)} + \underset{\text{carbon(coke)}}{C(s)} \longrightarrow \underset{\text{lead}}{Pb(s)} + \underset{\text{carbon monoxide}}{CO(g)}$$

Carbon monoxide is also a good reductant. This is formed when carbon undergoes incomplete combustion:

$$\underset{\text{carbon}}{2C(s)} + \underset{\text{oxygen}}{O_2(g)} \longrightarrow \underset{\text{carbon monoxide}}{2CO(g)}$$

Carbon dioxide is often produced in furnaces used for the extraction of metals:

$$ZnO(s) + CO(g) \longrightarrow Zn(s) + CO_2(g)$$

Metals above carbon in the reactivity series cannot be extracted from their oxides by heating with carbon. This is because the metal bonds to oxygen too strongly and the carbon is not reactive enough to remove it. So we have to use **electrolysis** to extract metals such as aluminium, magnesium and calcium.

It is possible to use electrolysis to extract metals less reactive than carbon. This is not done because much more energy is needed to carry out electrolysis compared with extraction using carbon.

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

Extension

Extracting zinc

The raw materials used in the extraction of zinc are zinc blende, coke (carbon) and air. The main ore of zinc is zinc blende which is zinc sulfide, ZnS. The ore is first crushed and treated to remove waste rock and other impurities. The zinc blende is then roasted (strongly heated) in air to form zinc oxide:

$$2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$$

The zinc oxide is then heated with coke (carbon) in a **blast furnace**.

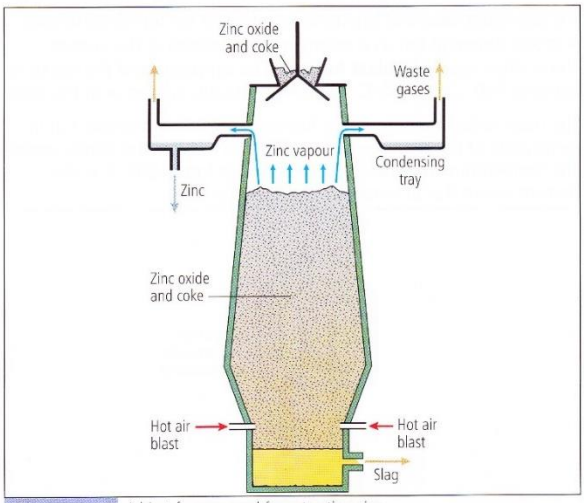


Figure 14.1.2 A blast furnace used for extracting zinc.

A blast of air is blown into the bottom of the furnace. The excess carbon reacts with oxygen in the air to form carbon monoxide:

$$2C(s) + O_2(g) \longrightarrow 2CO(g)$$

Higher up the furnace carbon monoxide reduces zinc oxide to zinc:

$$ZnO(s) + CO(g) \longrightarrow Zn(g) + CO_2(g)$$

The carbon dioxide formed can react with more carbon to reform carbon monoxide:

$$CO_2(g) + C(s) \longrightarrow 2CO(g)$$

Some zinc oxide may also react directly with the carbon:

$$ZnO(s) + C(s) \longrightarrow Zn(g) + CO(g)$$

The temperature in the furnace is higher than the boiling point of zinc. So the zinc vapour is carried up through the furnace by the stream of carbon monoxide and carbon dioxide. The vapour condenses in trays at the top of the furnace together with lead which is extracted at the same time. The zinc is then purified by distillation.

This method only produces about 20% of the world's zinc. Electrolysis of zinc sulfate is now preferred because this produces much purer zinc.

A zinc-smelting works.

SUMMARY QUESTIONS

1 Copy and complete using words from the list below:

bauxite carbon extract iron ores zinc

Rocks from which we can _____ metals are called _____. The main ore of aluminium is _____. Haematite is one of the main ores of _____. We can use _____ to reduce metal oxides such as iron oxide and _____ oxide.

2 Explain why you can not use carbon to extract magnesium from magnesium oxide.

3 Draw a flow diagram to show the main stages in the extraction of zinc using carbon. Extension

KEY POINTS

1 Metal oxides below carbon in the reactivity series are reduced by carbon when heated.

2 Metals more reactive than carbon are extracted by electrolysis.

3 Zinc is extracted from zinc oxide in a furnace using carbon as a reductant. Extension

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

14.2 Extracting Iron

LEARNING OUTCOMES

- State that iron can be extracted from haematite ore
- Describe the essential reactions in the blast furnace for the production of iron

Iron is the second most common metal in the Earth's crust. The main ore of iron, **haematite**, usually contains more than 60% iron. Haematite is largely iron(III) oxide. We extract iron by reduction of the iron(III) oxide with carbon.

The raw materials for making iron are haematite, coke, limestone and air. The haematite, coke and limestone are added at the top of the furnace. A strong current of hot air is blown in at the bottom of the furnace. This is why it is called a **blast furnace**. The temperature of the hot air is between 550 °C and 850 °C. This is high enough to react with the coke.

The main reductant in the blast furnace is carbon monoxide, but in some parts of the blast furnace carbon also reduces the iron(III) oxide. The temperature in the blast furnace ranges from 1500 °C at the bottom where the air enters to 250 °C at the top.

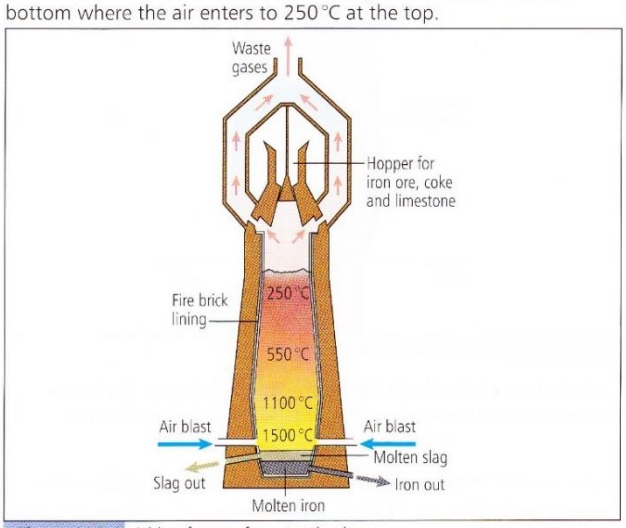


Figure 14.2.1 A blast furnace for extracting iron.

EXAMINER SAYS...

You will not be asked to draw the blast furnace. You should be prepared to answer questions related to a diagram of the blast furnace and the reactions involved.

The chemical reactions in a blast furnace

Extracting the iron

The chemical reactions below result in the production of iron from iron(III) oxide:

- At the bottom of the furnace the coke burns in the hot air blast to form carbon dioxide. This reaction is exothermic. The heat released helps heat the furnace.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

- The carbon dioxide reacts with the coke to form carbon monoxide:

$$CO_2(g) + C(s) \longrightarrow 2CO(g)$$

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points
(in space below)

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

- The carbon monoxide reduces the iron(III) oxide to iron:

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$$
iron(III) oxide + carbon monoxide → iron + carbon dioxide

Most of the iron is produced in this way. The iron flows to the bottom of the furnace and is removed from time to time as a liquid. It flows into moulds and is left to solidify.

Other reactions may take place in the furnace. In the hotter parts of the furnace, carbon reduces iron(III) oxide directly:

$$Fe_2O_3(s) + 3C(g) \longrightarrow 2Fe(l) + 3CO(g)$$

The hot waste gases exiting from the top of the furnace are used to heat the air going into the furnace thus reducing energy costs.

Why do we add limestone?

Haematite contains sand (silicon(IV) oxide) as a major impurity. The limestone (calcium carbonate) helps remove most of the impurities in the following way:

- The heat from the furnace decomposes the limestone:

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$
calcium carbonate (limestone) → calcium oxide + carbon dioxide

- The calcium oxide reacts with the silicon(IV) oxide to form a 'slag' of calcium silicate:

$$CaO(s) + SiO_2(l) \longrightarrow CaSiO_3(l)$$
calcium oxide + silicon(IV) oxide → calcium silicate (slag)

- The liquid slag runs down and forms a layer on top of the liquid iron because it has a lower density than iron. The slag is run off. The solid slag is used as a building material, particularly in road building.

DID YOU KNOW?

More than 2500 years ago people near Lake Victoria in Africa extracted iron from iron oxides at a temperature of 1400 °C.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

air blast coke haematite oxide reduces

We extract iron from iron ore in a _____ furnace. The commonest ore of iron is _____. The other raw materials used are _____, limestone and _____. Inside the blast furnace, carbon monoxide _____ the iron(III) _____ to iron.

2 Write word equations for these reactions which take place in the blast furnace during the extraction of iron:

a The reaction of iron(III) oxide with carbon monoxide.

b The reaction of calcium oxide with silicon(IV) oxide.

3 Explain why limestone is added to the blast furnace.

KEY POINTS

1 The raw materials used in the extraction of iron in the blast furnace are iron ore, coke, limestone and air.

2 In the blast furnace, carbon monoxide reduces iron(III) oxide to iron.

3 The thermal decomposition of limestone produces calcium oxide which reacts with silicon(IV) oxide impurities in the iron ore to form 'slag'.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

14.3 Iron into Steel

LEARNING OUTCOMES

- Describe how iron is converted into steel
- Understand the role of basic oxides and oxygen in steelmaking

The iron produced in the blast furnace is only about 95% pure. The impurities are mainly carbon but also include sulfur, silicon and phosphorus. The impurities make the iron very brittle – it breaks easily. If all the impurities are removed, the iron becomes very soft. In this condition, it is easily shaped but it is too soft for many uses. Pure iron also rusts very easily.

To make the iron strong, only some of the impurities are removed to produce various types of **steel**. Steel is an **alloy** of iron with carbon and/or with other metals.

Steelmaking

We make steel using a basic oxygen converter. This is often just called a steelmaking furnace. The converter is a very large bucket which can be tipped at an angle.

The impurities are removed from the iron and steel is made in the following way:

- The converter is tipped to one side and molten iron and scrap iron are poured in.
- The converter is put back into a vertical position. A water-cooled tube called an oxygen lance is lowered into the converter.
- Oxygen and powdered calcium oxide are blown onto the surface of the molten iron through the lance.
- The oxygen oxidises carbon, sulfur, silicon and phosphorus to their oxides. For example:

$$\underset{\text{silicon}}{Si} + O_2 \longrightarrow \underset{\text{silicon(iv) oxide}}{SiO_2}$$

$$4P + 5O_2 \longrightarrow 2P_2O_5$$

phosphorus + oxygen → phosphorus(v) oxide

DID YOU KNOW?

A steel weapon called the Falcata was made nearly 2500 years ago in the area which is now Spain and Portugal.

The carbon dioxide and sulfur dioxide escape from the converter because they are gases.

These reactions are very exothermic. The heat released in these oxidation reactions keeps the iron molten.

- Silicon and phosphorus oxides are solids. They are acidic oxides. So these react with the powdered calcium oxide which is basic. A **slag** is formed. For example:

$$\underset{\text{calcium oxide}}{CaO(s)} + \underset{\text{silicon(iv) oxide}}{SiO_2(l)} \longrightarrow \underset{\text{calcium silicate (slag)}}{CaSiO_3(l)}$$

The slag floats on the surface of the molten iron and is removed.

- The amount of carbon in the steel is controlled by the amount of oxygen blown into the impure iron. The longer the oxygen blast the more carbon is removed.

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

- After the required amount of carbon has been removed, other elements such as chromium and nickel are added to make particular types of steel.

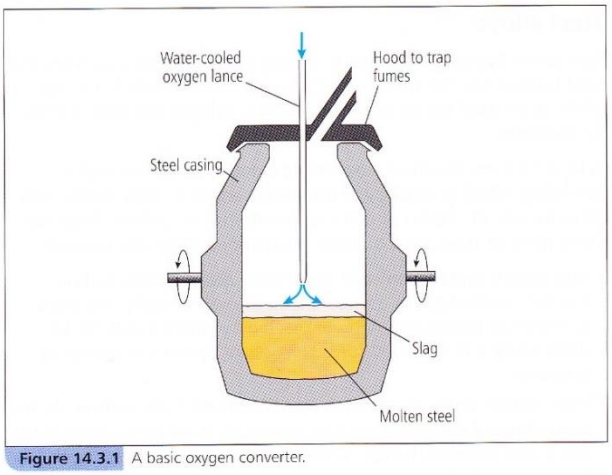


Figure 14.3.1 A basic oxygen converter.

A modern converter can make up to 350 tonnes of medium quality steel in 40 minutes. High quality steel is usually made using an electric furnace. In this process the high temperatures needed to keep the iron molten are produced by an electric current.

Pouring molten steel into moulds can be quite spectacular.

EXAMINER SAYS...

Do not confuse steelmaking with the blast furnace. In steelmaking the impurities are removed from the impure iron we get from the blast furnace. In the blast furnace the impure iron is extracted from the iron ore.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

basic carbon converter oxide oxidises silicon slag surface

The iron from the blast furnace contains about 5% _____ and other impurities. These impurities are removed in a _____ oxygen _____. Oxygen is blown onto the _____ of the iron. This _____ the impurities. Calcium _____ is added to remove oxides of _____ and phosphorus as _____.

2 Explain why calcium oxide is added to the basic oxygen converter.

3 Explain how we get different types of steel by using the basic oxygen converter.

KEY POINTS

1 The iron from the blast furnace contains 5% impurities, most of which is carbon.

2 Impurities are removed from iron using a basic oxygen converter.

3 Pure iron is too weak and soft for it to be very useful.

4 The percentage of carbon in steel is controlled by the amount of oxygen blown into the steel.

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

A6 (&A8). Cue questions
Fill this in AFTER finishing the section

14.4 Uses of Metals

LEARNING OUTCOMES

- Explain why aluminium is used to make aircraft and food containers
- Describe why different steel alloys are used for specific purposes
- Extension: Describe the uses of zinc and copper and describe how their uses are related to their properties

DID YOU KNOW?

Although coins have been made of metal for many centuries, in China 2800 years ago model farming tools were used for money.

EXAMINER SAYS...

Make a list of all the substances in the syllabus whose uses you need to know. Divide the page into two with the names down one side and the uses on the other. Then test yourself.

Activities To Do

(complete as you are reading)

A1. Translating - 翻译

A2. Underlining

A5. Key Points

(in space below)

Steel alloys

Pure iron is too soft and weak to be very useful but the iron from the blast furnace has too much carbon in it to make it useful. It is too brittle to be used for constructions such as bridges and steel frames for buildings.

In Unit 14.3 we described how the amount of carbon in steel is controlled. **Steel** is an **alloy** of iron with carbon or with carbon and other metals. All steels contain a small amount of carbon. There are many types of steel. Each of these is used for a particular purpose:

- Mild steel is low carbon steel. It contains about 0.25% carbon. It is soft, malleable and can be drawn into wires easily. We use it to make car bodies and parts of machinery where it will not be worn away. It is also used for buildings and general engineering purposes.
- High carbon steels contain between 0.5% and 1.4% carbon. As the percentage of carbon in the steel increases, it becomes more brittle. But it also becomes harder. These steels are used for tools such as hammers and chisels.
- Low alloy steels contain between 1% and 5% of other metals such as nickel, chromium, manganese and titanium. They are hard and do not stretch much. Nickel steels are used for bridges where strength is needed and for bicycle chains. Tungsten steel is used for high-speed tools because it does not change shape at high temperatures.
- Stainless steels are high alloy steels. They may contain up to 20% of chromium. Many stainless steels contain 70% iron, 20% chromium and 10% nickel. They are very strong and resist corrosion. So they are used in the construction of pipes and towers in chemical factories. Stainless steel is also used to make cutlery – knives, forks and spoons. Surgical instruments are also made from stainless steel.

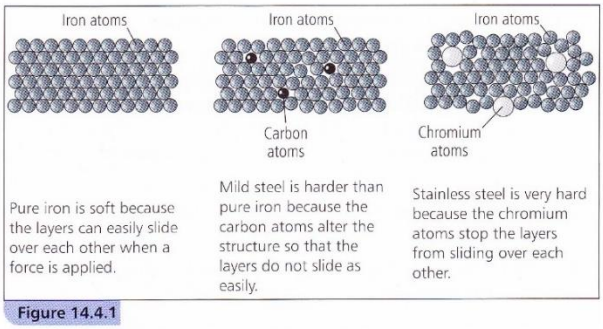


Figure 14.4.1

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

A6 (&A8). Cue questions part 2
Fill this in AFTER finishing the section

Uses of other metals and alloys

Aluminium

Aluminium is used for making aircraft bodies because it is lightweight – it has a low density. It is also quite strong. Most aircraft are made from aluminium alloys containing about 90% aluminium and smaller amounts of zinc and copper.

Some food containers and cooking foil are made from aluminium. This is because there is an unreactive oxide layer on its surface which does not flake off (see Unit 13.4). This oxide layer does not react with the acids that are present in many foods.

Aircraft bodies are made from alloys of aluminium because these alloys are strong yet lightweight.

Extension

Zinc

Zinc is used to **galvanise** iron or mild steel to prevent rusting (see Unit 15.7). To galvanise a steel object, we dip the object into liquid zinc. The zinc forms a coating on the surface of the steel. About a third of the zinc produced in the world is used to galvanise steel. Galvanised steel is used for roofing because it is weather resistant.

Copper

Copper is used for electrical wiring because of its high electrical conductivity. It is one of the most malleable and ductile metals so it can easily be shaped and drawn into wires. It is also used for the base of cooking pans because it is an excellent conductor of heat.

Brass

Brass is an alloy of 70% copper and 30% zinc. It is stronger than copper and does not corrode. Although it is strong, it can still be easily beaten into shape. Its gold colour makes it attractive. So it is used to make musical instruments, door handles, ornaments and screws.

SUMMARY QUESTIONS

1 Copy and complete using the words below:

car carbon cutlery different mild stainless

We use _____ types of steel for different jobs. Low _____ steel, often called _____ steel, is used to make _____ bodies and machinery. We use _____ steel to make _____ and parts of chemical factories.

2 Explain why aluminium is used to make food containers.

3 Describe the advantages of using steel alloys rather than pure iron.

KEY POINTS

1 The properties of iron are changed by adding controlled amounts of other metals or carbon to make steels.

2 Mild steel is used in building and for making car bodies.

3 Stainless steel is used for making chemical plant and cutlery.

4 Steel is often covered with a layer of zinc to protect it from rusting. This is called galvanising. (Extension)

A3. Answers to Summary Questions (& Activity 4 Checking answers)

A9 Top Tips - *Do this after you've taken the end of topic test*. Write any difficult, odd or unexpected marks you come across from your tests and revision and especially from working through past exam questions

Mind Map 1 of Section 10.3 & 10.4

(Chapter 14) Summary & Exam Questions for Sections 10.3 & 10.4

These questions can be looked at, but they have limited use if you are working towards an A*, they could be attempted under test-like conditions and used as a revision exercise, for instance

SUMMARY QUESTIONS

1 Match each metal on the left with its ore on the right.

iron	rock salt
aluminium	zinc blende
zinc	bauxite
sodium	haematite

2 Draw a diagram of a blast furnace. On your diagram show:

- where the solid raw materials are loaded into the furnace
- where air enters the furnace
- where the iron and slag collect.

3 Copy and complete using the words from the list below.

air blast calcium coke decomposes impurities monoxide slag

Iron is extracted in a _____ furnace from iron ore using carbon _____ as a reducing agent. The carbon monoxide is formed when _____ burns in a blast of _____. The limestone added to the blast furnace _____ to form _____ oxide. Calcium oxide combines with the _____ in the iron ore to form _____.

4 Match each metal on the left with its use on the right.

aluminium	galvanising iron roofs
mild steel	electrical wiring in the home
stainless steel	aircraft bodies
copper	cutlery
zinc	car bodies

5 Two methods for extracting metals are (i) heating with carbon and (ii) electrolysis. Which of these methods is best used to extract each of the following metals?

(a) sodium

(b) lead

(c) calcium

(d) iron

(e) aluminium

EXAM-STYLE QUESTIONS

1 Which one of these statements about the extraction of iron in a blast furnace is true?

A Limestone is added to combine with excess carbon dioxide.

B A slag of iron(III) oxide forms at the bottom of the furnace.

C Hot air is blown in at the top of the furnace.

D Carbon monoxide reduces iron(III) oxide to iron.

(Paper 1) *[1]*

2 Calcium oxide is added to a steelmaking furnace to:

A oxidise basic oxides

B oxidise carbon to carbon dioxide

C react with acidic impurities

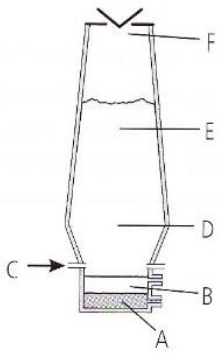
D react with silicon to form silicon dioxide.

(Paper 1) *[1]*

3 Iron is extracted in a blast furnace.

(a) Name the four raw materials used to extract iron. *[4]*

(b) The diagram shows a blast furnace.



Extension

6 Put the following phrases about the extraction of zinc in the correct order.

A zinc vapour rises up the furnace

B zinc oxide is heated with coke to produce zinc

C zinc sulfide is roasted in air to produce zinc oxide

D the zinc condenses in trays

A6 (&A8). Cue questions *Fill this in AFTER finishing the section*	***Answers to summary and Exam Questions*** *– Remember to check them AFTERWARDS and make notes on anything difficult or that you missed*

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

Which letter in the diagram shows:

(i) where the solid raw materials are put into the furnace *[1]*

(ii) where the furnace is hottest *[1]*

(iii) where the slag is collected? *[1]*

(c) In the blast furnace, carbon monoxide reacts with iron(III) oxide.

(i) Write a word equation for this reaction. *[1]*

(ii) The carbon monoxide is formed by carbon dioxide reacting with excess carbon. Write a symbol equation for this reaction. *[2]*

(Paper 2)

4 Iron is converted to steel by blowing oxygen into molten iron in a basic oxygen converter.

(a) Name three impurities present in the iron extracted from the blast furnace. *[3]*

(b) Explain the function of the oxygen 'blast' in steelmaking. *[1]*

(c) Powdered calcium oxide is added at the same time as the oxygen. Why is calcium oxide added? *[2]*

(d) Stainless steel is used for many purposes.

(i) State one use of stainless steel. *[1]*

(ii) What is the difference between stainless steel and iron? *[2]*

(iii) Stainless steel is an alloy. What do you understand by the term *alloy*? *[1]*

(Paper 2)

5 Some of the metals in the reactivity series are shown below:

sodium calcium zinc iron copper

most reactive ⟶ *least reactive*

(a) (i) State the names of two metals from this list that can be extracted by heating with carbon. *[2]*

(ii) State the names of two metals from this list that are extracted using electrolysis. *[2]*

(b) Aluminium can be extracted by electrolysis. State two uses of aluminium. *[2]*

(c) Carbon is used to extract tin from tin(IV) oxide, SnO_2.

(i) What condition is needed for this extraction? *[1]*

(ii) The products of the reaction are tin and carbon monoxide. Write a symbol equation for the extraction of tin. *[2]*

(Paper 2)

6 Zinc is extracted from its sulfide ore.

(a) State the name of the sulfide ore of zinc. *[1]*

(b) The sulfide ore is first converted to zinc oxide. Write a balanced equation for this reaction. *[2]*

(c) The zinc oxide is reduced in a blast furnace. Describe in outline how zinc is extracted from zinc oxide. *[4]*

(d) At high temperatures, zinc oxide reacts with carbon. Explain why this is a redox reaction in terms of electron transfer. *[2]*

(e) (i) Give one use of zinc. *[1]*

(ii) Explain why zinc is used for the purpose you stated in part (i). *[1]*

(Paper 3)

7 Steel is an alloy of iron with controlled amounts of carbon and other metals added.

(a) Explain how the amount of carbon in the steel is controlled. *[2]*

(b) One of the impurities in the iron from the blast furnace is phosphorus. Explain how phosphorus is removed from the iron when steel is made in the basic oxygen converter. *[3]*

(c) State two uses of mild steel. *[1]*

(d) (i) Draw the structure of a typical alloy. *[2]*

(ii) Explain why steel is harder than pure iron. *[2]*

(e) Brass is an alloy. State the names of the metals present in brass. *[1]*

(Paper 3)

A6 (&A8). Cue questions *Fill this in AFTER finishing the section*	***Answers to summary and Exam Questions*** *– Remember to check them AFTERWARDS and make notes on anything difficult or that you missed*

A7. Summary Section- *Do this a after you have answered the past exam questions* and write, in your own words, only one or two sentences that sums up the important points on this page

Mind Map 2 of Section 10.3 & 10.4

Glossary of Topic 10

For games and activities, was well as tests based on the keywords (English keywords and English definitions) of this topic and all others go to this website:

https://quizlet.com/Patrick_Brannac4/folders/igcse-chemistry-cie-0620-glossary-english-words-by-topic?x=1xqt&i=ga2m8

For the same set with English keyword and English definitions matched to google translated Chinese:

https://quizlet.com/Patrick_Brannac4/folders/igcse-chemistry-cie-0620-glossary?x=1xqt&i=ga2m8

Key words	Google translation
alkali metals elements in Group I of the Periodic Table; they are the most reactive group of metals	元素周期表第 I 族中的**碱金属元素**；**它**们是最活泼的金属
alloys mixtures of elements (usually metals) designed to have the properties useful for a particular purpose; for example, solder (an alloy of tin and lead) has a low melting point	具有特定目的有用特性的元素（通常为金属）混合物的合金；例如，焊料（锡和铅的合金）的熔点低
amphoteric hydroxides which can react with both acids and alkalis to produce salts; for example, zinc hydroxide; certain metal oxides can also be amphoteric	可与酸和**碱反**应生成盐的两性氢氧化物；例如，氢氧化锌；某些金属氧化物也可以是两性的
basic oxide of a metal that will react with acids to neutralize the acid	与酸反应中和酸的金属的碱性氧化物
basic oxygen process the process used to make steel from iron from the blast furnace: oxygen is blown into the molten iron using an 'oxygen lance' and lime is added to remove non-metallic impurities	基础氧气工艺：用于从高炉中的铁制造钢的工艺：使用"**氧气**喷枪"将**氧气吹入**铁水中，并添加石灰以去除非金属杂质
blast furnace a furnace for smelting iron ores such as hematite (Fe2O3) with carbon to produce pig (or cast) iron (in a modified form the furnace can be used to extract metals such as zinc)	高炉：用**碳冶**炼赤铁矿（Fe2O3）等铁矿石以生产生铁（或铸铁）的炉子（该炉的改进形式可用于提取锌等金属）
carbon steel alloys of iron and carbon only; the amount of carbon in steels can vary between 0.2% and 1.5%	仅含铁和碳的碳钢合金；钢中的碳含量可以在 0.2％至 1.5％之间变化
corrosion the name given to the process that takes place when metals and alloys are chemically attacked by oxygen, water or any other substances found in their immediate environment	腐蚀当金属和合金受到其周围环境中的氧气，水或任何其他物质的化学腐蚀时所发生的过程的名称
decomposition (see also thermal decomposition) a type of chemical reaction where a compound breaks down into simpler substances	分解（**另**见热分解），一种化学反应，其中化合物分解成更简单的物质
displacement reaction a reaction in which a more reactive element displaces a less reactive element from a solution of its salt	置换反应一种反应，其中反应性较高的元素从其盐溶液中置换反应性较低的元素
galvanizing the protection of iron and steel objects by coating with a layer of zinc	通过镀锌层来保护钢铁物体
metalloid (semi-metal) element which shows some of the properties of metals and some of nonmetals; for example, boron and silicon	准金属（半金属）元素，具有金属和非金属的某些特性；例如硼和硅
metals a class of chemical elements (and alloys) which have a characteristic shiny appearance and are good conductors of heat and electricity	金属是一类化学元素（和合金），具有特征性的光泽外观，并且是良好的热和电导体
ore a naturally occurring mineral from which a metal can be extracted	矿石天然矿物，可以从中提取金属
reactivity series of metals an order of reactivity, giving the most reactive metal first, based on results from a range of experiments involving metals reacting with oxygen, water, dilute hydrochloric acid and metal salt solutions	根据一系列**涉及金属与氧气**，**水**，**稀**盐酸和金属盐溶液反应的实验结果，金属的一系列反应性是反应性的顺序，从而使金属活性最高

Key words	Google translation
redox reaction a reaction involving both reduction and oxidation reducing agent a substance which will reduce another in a redox reaction	**氧化**还原反应一种同时包含还原剂和氧化还原剂的反应，一种物质将在氧化还原反应中还原另一种物质
reduction there are three definitions of reduction: (i) a reaction in which oxygen is removed from a compound; (ii) a reaction involving the gain of electrons by an atom, molecule or ion; (iii) a reaction in which the oxidation state of an element is decreased	还原有三种还原定义：（i）从化合物中除去**氧的反**应；（ii）**涉及通**过原子，分子或离子获得电子的反应；（iii）元素的**氧化**态降低的反应
rust a loose, orange-brown, flaky layer of hydrated iron(III) oxide, Fe2O3.xH2O, found on the surface of iron or steel	生锈在铁或钢表面上发现的疏松的橙棕色鳞片状水合氧化铁（Fe2O3.xH2O）
strong alkali an alkali that is completely ionized when dissolved in water – this produces the highest possible concentration of OH−(aq) ions in solution; for example, sodium hydroxide	强**碱**：**一种溶于水**时会完全离子化的碱-这会在溶液中产生最高浓度的 OH-（aq）**离子**；**例如**氢氧化钠
transition elements (or transition metals) elements from the central region of the Periodic Table – they are hard, strong, dense metals that form compounds which are often colored	元素周期表中心区域的过渡元素（或过渡金属）元素–它们是坚硬，坚固，致密的金属，通常形成有色化合物

Chapter 13 Summary Questions Mark Scheme

Summary Questions 13.1 p159

1 mixture: non-metals; alloy; stronger; layers; slide

2 the presence of a second type of atom disrupts the layered structure so that the layers cannot slide so easily

3a/b see fig 13.1.3 p159

Summary Questions 13.2 p161

1 potassium; cold; hydroxide; iron; steam; hydrogen

2 it is not very reactive

3a will not reacts

b will react to form tin oxide and release hydrogen

Summary Questions 13.3 p163

1 displaces; less; solution; more; valency

2a $CuSO_4 + Mg \rightarrow MgSO_4 + Cu$

b $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

3 iron is above copper in the reactivity series

Summary Questions 13.4 p165

1 below: reduced; metals; heated; reductant; oxygen

2a $2ZnO + C \rightarrow 2Zn + CO_2$

b $Mg + CuO \rightarrow MgO + Cu$

3 When just made, the aluminium reacts because it is above hydrogen in the reactivity series. After a few minutes the aluminium reacts with oxygen in the air to form an unreactive oxide layers which prevents reaction.

Summary Questions 13.5 p167

1 alkali; heated; nitrite; less; dioxide; oxygen

2a $Cu(OH)_2 \rightarrow CuO + H_2O$

b $2Ca(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$

3 lithium has a much smaller ion than the other Group I metals so has a higher charge density. The charge density is more similar to those of Group II metals.

Chapter 13 Summary Questions p168

1 water; sodium/ potassium; potassium/ sodium; oxygen; alkali; hydroxides; iron; powder; oxide

2a calcium, magnesium, zinc, iron, lead

b calcium (magnesium reacts extremely slowly)

c calcium, magnesium, zinc, iron, ALLOW: lead

di K most reactive / K is above Ca

ii below Cu

3 sodium – reacts with water to form alkaline solution
copper – pinkish brown metal
iron – reacts with steam but not with cold water
lead – grey, fairly unreactive metal
magnesium - reactive metals that burns with a white light

4 The more readily the positive ion is formed the more reactive the metal (since they lose electrons more readily)

5 It has a protective oxide layer on its surface which is unreactive with acids

6a $2Mg + O_2 \rightarrow 2MgO$

b $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

c $Ca(OH)_2 \rightarrow CaO + H_2O$

d $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

e $Fe_2O_3 + 3Mg \rightarrow 2Fe + 3MgO$

7 breakdown of compound by heating

Chapter 13 Exam Questions Mark Scheme

1 B [1]

2 C [1]

3a sodium, calcium (ALLOW sodium, calcium, magnesium) [1]

bi Zn / Pb [1]

ii 3; 4; 4 (one mark each) [3]

ci magnesium + hydrochloric acid → magnesium chloride + hydrogen [1]

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ [2]

1 mark for formulae

1 mark for balance

ii test with lighted splint; [1]

pops/ explodes [1]

di Any 2 of: [2]

white powder forms or white powder escapes/

brown or pink specks or particles formed/

violent reaction/

light or flame produced

ii magnesium + copper(II) oxide → copper + magnesium oxide [1]

iii magnesium [1]

4a mixture of metals / mixture of metal(s) with non-metals; [1]

bi Any two of: [2]

zinc coated with pink or brown substance/

zinc becomes smaller in size ALLOW: dissolves/

colour of copper sulfate fades

ii zinc + copper(II) sulfate → zinc sulfate + copper [1]

iii redox / displacement [1]

ci K higher in reactivity series / Zn lower in reactivity series [1]

ii $2K + 2H_2O \rightarrow 2KOH + H_2$ [2]

1 mark for formulae

1 mark for balance

5a Zn; [1]

because it removes the oxygen from then CuO [1]

b Zn loses (2) electrons; [1]

Cu gains (2) electrons [1]

c Zn is more reactive than Cu/ Zn is better at losing electrons than Cu [1]

d Mg loses electrons more easily than Cu; [1]

so removes the oxygen form the oxide more readily/ magnesium is a better reductant [1]

e $2Cu(NO_3)_2(s) \rightarrow 2CuO(s) + 4NO_2(s) + O_2(s)$ [3]

1 mark for formulae

1 mark for balance

1 mark for state symbols (depends on correct formulae but not balance)

6ai Any 2 of: [2]

sodium moves about, magnesium does not/

sodium floats, magnesium does not/

sodium produces lots of bubbles, magnesium does not/

sodium forms a ball, magnesium does not

ii $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$ [3]

1 mark for formulae

1 mark for balance

1 mark for state symbols for Mg/ H_2O and H_2 IGNORE MgO (depends on correct formulae but not balance)

bi breakdown of a substance by heating [1]

ii $2NaNO_3 \rightarrow 2NaNO_2 + O_2$ [2]

1 mark for formulae

1 mark for balance

iii magnesium nitrate → magnesium oxide + nitrogen dioxide + oxygen [2]

2 marks if all correct
1 mark for any two correct products

ci heat mixture of magnesium and aluminium oxide to a high temperature / heat strongly [1]

ii Any one of: [1]
hazardous or dangerous reaction/
difficulty in obtaining aluminium from the (fused) mixture/

iii aluminium forms an oxide layer; [1]
which is unreactive [1]

Chapter 14 Summary Questions Mark Scheme

Summary Questions 14.1 p171

1 extract; ores; bauxite; iron; carbon; zinc

2 C is below Mg in the reactivity series

3 zinc blend/ zinc sulfide
↓
reacts with oxygen to form ZnO + SO_2
↓
ZnO heated in blast furnace with C at high temperature
↓
C oxidised to CO
↓
ZnO reduced by CO to Zn
↓
Zn evaporates in furnace to condenses in trays at the top

Summary Questions 14.2 p173

1 blast; haematite; air/ coke; coke/ air; reduces; oxide

2a iron(III) oxide + carbon monoxide → iron + carbon dioxide

b calcium oxide + silicon(IV) oxide → calcium silicate

3 limestone decomposes to form calcium oxide; which reacts with silicon(IV) oxide impurities in the ore to form slag / calcium silicate

Summary Questions 14.3 p175

1 carbon; basic; converter; surface; oxidises; oxide; silicon; slag

2 to combine with the solid oxides of Si and P and form a slag which can be removed form the surface

3 oxygen blast removes the required amount of carbon;
other metals e.g. Cr, Ni added in the required proportions

Summary Questions 14.4 p177

1 different; carbon; mild; car; stainless; cutlery

2 aluminium has an unreactive oxide layer on its surface; so wont react with acid in the food
ALLOW: thin sheets are easily bent to form containers

3 steel alloys are stronger/ harder than iron/ iron is brittle compared with steel/
steel alloys are more resistant to corrosion

Chapter 14 Summary Questions p178

1 iron – haematite
aluminium – bauxite
zinc – zinc blende
sodium – rock salt/ halite

2 see fig 14.2.1 p172

3 blast; monoxide; coke; air; decomposes; calcium; impurities; slag

4 aluminium – aircraft bodies
mild steel – car bodies
stainless steel – cutlery
copper – electrical wiring in the home
zinc – galvanising

5a electrolysis
b heating with carbon
c electrolysis
d heating with carbon
e electrolysis

6 C, B, A, D

Chapter 14 Exam Questions Mark Scheme

1 D [1]

2 C [1]

3a iron ore/ named iron ore; coke/ carbon; limestone; air (1 mark each) [4]

bi F [1]

ii D [1]

iii B [1]

ci iron(III) oxide + carbon monoxide → iron + carbon dioxide [1]

ii $CO_2 + C \rightarrow 2CO$ [2]
1 mark for correct formulae
1 mark for balance

4a Any 3 of: C/ P/ Si/ S (1 mark each) [3]

b oxidises the impurities to their oxides (which can then be removed) [1]

c to react with Si and P oxides [1]

di any one use e.g. cutlery/ chemical plant [1]

ii stainless steel is an alloy but iron is a pure metal; [1]
stainless steel contains added metals / named metals but iron contains non-metal impurities/ named impurities [1]
ALLOW: stainless steel contains less carbon than iron
ALLOW: stainless steel is stronger than iron

iii mixture of metals / mixture of metal(s) with non-metal [1]

5ai Any 2 of: Zn/ Fe/ Cu (1 mark each) [2]

ii sodium; calcium (1 mark each) NOT: copper [2]

b Any 2 uses of aluminium e.g. aircraft bodies/ food containers/ car bodies/ high voltage electricity cables (1 mark each) [2]

ci heat [1]

ii $SnO_2 + 2C \rightarrow Sn + 2CO$ [2]
1 mark for correct formulae
1 mark for balance

6a zinc blende [1]

b $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ [2]
1 mark for correct formulae
1 mark for balance

c Any 4 of: [4]
C burns in air to form CO/
Zn reduced by CO/
some ZnO reduced by C/
idea of high temperature in blast furnace/
Zn vapour rises up blast furnace or condenses in trays at top of furnace

d Zn gains electrons [1]
C loses electrons [1]

ei galvanising/ specific uses of galvanising e.g. coating on roofs [1]

ii stops oxygen and water getting to the iron/ sacrificial metal/ prevents iron underneath from rusting [1]

7a Any 2 of: [2]
oxygen blown (onto the surface of the hot iron/ into the iron) /
carbon oxidised to carbon dioxide which escapes/
carbon content of iron decreases/
amount of carbon in steel determined by length of time of oxygen blast

b P oxidised to phosphorus oxide/ P_2O_5; [1]
CaO (blown into furnace) reacts with phosphorus oxide; [1]
The slag formed on the surface of the steel is removed [1]

c Any two uses: e.g. car bodies/ buildings/ bridges/ garden tools/ garden furniture (1 mark each) [2]

di see fig 14.4.1 p176 [2]
1 mark for mixture of metal atoms randomly arranged;
1 mark for different sized alloying atoms and atoms in distorted layers

ii in pure iron the layers can slide over each other; [1]
in steel the different sized atoms prevent the layers from sliding [1]

e copper + zinc (both needed) [1]