

3.1 Extracting metals

Key points

- Metals are usually found in the Earth's crust. They are often combined chemically with other elements such as oxygen.
- An ore contains enough metal to make it worth extracting the metal.
- The method we use to extract a metal depends on its reactivity.
- Unreactive metals are found in the Earth as the metal.
- The oxides of metals less reactive than carbon can be reduced using carbon.



An open-cast copper mine

- Rock that contains enough of a metal or a metal compound to make it worth extracting the metal is called an **ore**.
- Mining ores often involves digging up large amounts of rock. The ore may need to be concentrated before the metal is extracted. These processes can produce large amounts of waste and may have major impacts on the environment.

1 What is an ore?

- A few unreactive metals, low in the **reactivity series**, such as gold are found in the Earth as the metal. Gold can be separated from rocks by physical methods. However, most metals are found as compounds. So then the metals have to be extracted by chemical reactions.
- Metals can be extracted from compounds by displacement using a more reactive element. Metals which are less reactive than carbon can be extracted from their oxides by heating with carbon. A **reduction** reaction takes place as carbon removes the oxygen from the oxide to produce the metal. This method is used commercially if possible.

- 2 a Name two metals that have oxides that can be reduced by carbon?
b What do we call the removal of oxygen from a metal oxide?

Bump up your grade

If you are taking the Higher Tier paper, you should be able to write a balanced symbol equation for the reduction of a named metal oxide by carbon.

Key words: ore, reactivity series, reduction

3.2 Iron and steels

Key points

- Iron oxide is reduced in a blast furnace to make iron.
- Iron from the blast furnace is too brittle for many uses.
- Most iron is converted into alloys called steels.
- Steels contain carefully controlled quantities of carbon and other elements.

- Many of the ores used to produce iron contain iron(III) oxide. Iron(III) oxide is reduced at high temperatures in a **blast furnace** using carbon. The iron produced contains about 96% iron. The impurities make it hard and brittle and so it has only a few uses as **cast iron**. Removing all of the carbon and other impurities makes pure iron, but this is too soft for many uses.

1 Why does iron from the blast furnace have only a few uses?

- Most iron is used to make **steels**. Steels are **alloys** of iron because they are mixtures of iron with carbon and other elements. Alloys can be made so that they have properties for specific uses.



Steels have many uses in modern buildings

- The amounts of carbon and other elements are carefully adjusted when making steels. Low-carbon steels are easily shaped and high-carbon steels are hard.
- Some steels, such as **stainless steels**, contain larger quantities of other metals. They resist corrosion.

➡ 2 Why are steels more useful than pure iron?

Key words: blast furnace, cast iron, steel, alloy, stainless steel

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Key points

- Aluminium and titanium resist corrosion. They also have low densities compared with other strong metals.
- Aluminium and titanium cannot be extracted from their oxides using carbon.
- Aluminium and titanium are expensive because extracting them involves many stages and requires large amounts of energy.



Titanium turbine blades in a jet engine

3.3 Aluminium and titanium

- **Aluminium** has a low density and, although it is quite high in the reactivity series, it is resistant to corrosion.
- Aluminium is more reactive than carbon and so its oxide cannot be reduced using carbon.
- It has to be extracted by electrolysis of molten aluminium oxide. The process requires high temperatures and a lot of electricity. This makes aluminium expensive to extract.
- Pure aluminium is not very strong, but aluminium alloys are stronger and harder. They have many uses.

➡ 1 Why is it expensive to extract aluminium from its ore?

- **Titanium** is resistant to corrosion and is very strong. It also has a low density compared with other strong metals.
- Titanium oxide can be reduced by carbon, but the metal reacts with carbon making it brittle.
- Titanium is extracted from its ore by a process that involves several stages and large amounts of energy. The high costs of the process make titanium expensive.

➡ 2 Why is titanium a very useful metal for making aircraft engines?

AQA Examiner's tip

You do not need to remember any further details of the methods used to extract these metals.

Bump up your grade

Learn some of the properties and uses for each of the metals named in this chapter.

Key words: aluminium, titanium

3.4 Extracting copper

Key points

- Most copper is extracted from copper-rich ores by smelting.
- Copper can be purified by electrolysis.
- Bioleaching and phytomining are new ways to extract copper from low-grade ores.
- Copper can be obtained from solutions of copper salts by displacement or electrolysis.



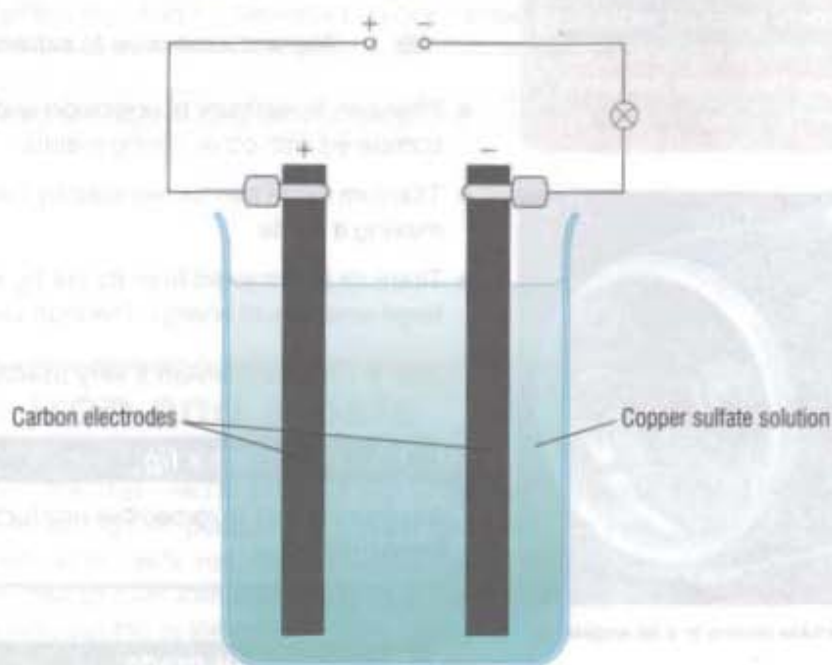
Pure copper plates produced by electrolysis

- Copper can be extracted from **copper-rich ores** by **smelting**. This means heating the ore strongly in a furnace.
- Smelting produces impure copper, which can be purified by electrolysis.
- Smelting and purifying copper ore require huge amounts of heating and electricity.
- Copper-rich ores are a limited resource. Scientists are developing new ways of extracting copper from low-grade ores. These methods can have less environmental impact than smelting.
- **Phytomining** uses plants to absorb copper compounds from the ground. The plants are burned and produce ash from which copper can be extracted.
- **Bioleaching** uses bacteria to produce solutions containing copper compounds.

➡ 1 Why are new ways of extracting copper being researched?

- Solutions of copper compounds can be reacted with a metal that is more reactive than copper, such as scrap iron, to **displace** the copper.
- Copper can also be extracted from solutions of copper compounds by electrolysis.

➡ 2 What three ways can be used to produce copper metal from its compounds?



Extracting copper metal using electricity

Key words: copper-rich ore, smelting, phytomining, bioleaching, displace

Key points

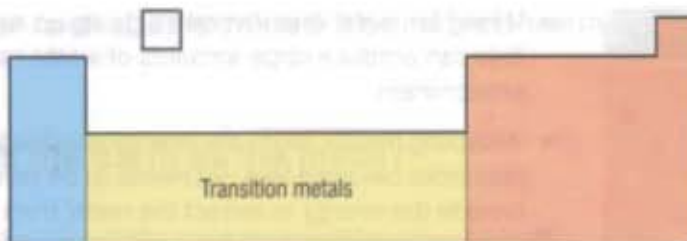
- The transition metals are found in the central block of the periodic table.
- Transition metals have properties that make them useful for building and making things.
- Most of the metals we use are alloys.



Alloys are used to make some musical instruments

AQA Examiner's tip

When asked for the properties of alloys, many students include cost or cheapness but cost is not a property of a substance.



The position of the transition metals in the periodic table

- Elements from the central block of the periodic table are known as the **transition metals**.
- They are all metals and have similar properties.
- They are good conductors of heat and electricity.
- Many of them are strong, but can be bent or hammered into shape. These properties make them useful as materials for buildings, vehicles, containers, pipes and wires.

➡ 1 *What properties make transition metals useful materials for making things?*

- Copper is a very good conductor of heat and does not react with water. It can be bent but it is hard enough to keep its shape. These properties make it useful for making pipes and tanks in water and heating systems. It is a very good conductor of electricity as well and so it is used for electrical wiring.

➡ 2 *What properties are needed for electrical wiring?*

- Most of the metals we use are not pure elements.
- Pure iron, copper, gold and aluminium are soft and easily bent. They are often mixed with other elements to make alloys that are harder so that they keep their shape.
- Iron is made into steels (see C1 3.2).
- Gold used for jewellery is usually an alloy.
- Most of the aluminium used for buildings and aircraft is alloyed.
- Copper alloys include bronze and brass.

➡ 3 *Why is the gold used for wedding rings mixed with other metals?*

Key words: transition metal

Key points

- There are social, economic and environmental issues associated with exploiting metal ores.
- Recycling saves energy and limited resources.
- There are drawbacks as well as benefits from the use of metals in structures.



Steel girders are used in many buildings

- Mining for metal ores involves digging up and processing large amounts of rock. This can produce large amounts of waste material and affect large areas of the environment.
- Recycling metals saves the energy needed to extract the metal. Recycling saves resources because less ore needs to be mined. Also, less fossil fuel is needed to provide the energy to extract the metal from its ore.



1 Why should we recycle aluminium cans?

- The benefits of using metals in construction should be carefully considered against the drawbacks. Some examples are shown in the table below.

Some benefits of using metals in construction	Some drawbacks of using metals in construction
<ul style="list-style-type: none"> • they are strong • they can be bent into shape • they can be made into flexible wires • they are good electrical conductors 	<ul style="list-style-type: none"> • obtaining metals from ores causes pollution and uses up limited resources • metals are more expensive than other materials such as concrete • iron and steel can rust

2 Use the information in this chapter to explain the benefits and drawbacks of using steel for girders in buildings.

AQA Examiner's tip

You do not need to remember details or specific examples of uses of metals beyond those given in C1 Topics 3.1 to 3.5, but you should be prepared to discuss and evaluate information you are given in the examination.

Bump up your grade

To gain the highest grade, you should be able to write a clear evaluation of information you are given about metals, identifying benefits and drawbacks and giving a conclusion.

- 1 What is the name for rock that is mined from which metal can be extracted economically?
- 2 Why is gold found in the Earth as the metal?
- 3 What are the typical properties of 'transition metals'?
- 4 Explain why most of the metals we use are not pure elements.
- 5 Describe a reaction that is used to get iron from iron oxide. Write a word equation for the reaction.
- 6 Name three types of steel and give an important property for each one.
- 7 Explain why all steels are alloys.
- 8 Give three properties that make aluminium a useful metal.
- 9 Give three reasons why titanium is expensive.
- 10 Suggest three reasons why we should recycle iron and steel.
- 11 Name two methods, other than smelting, of extracting copper from low-grade ores. Describe how one of these methods can be used to make copper.
- 12 Balance these equations:

$$\text{Fe}_2\text{O}_3 + \text{C} \rightarrow \text{Fe} + \text{CO}_2$$

$$\text{Na} + \text{TiCl}_4 \rightarrow \text{Ti} + \text{NaCl}$$

[H]

Chapter checklist

Tick when you have:

reviewed it after your lesson



revised once – some questions right



revised twice – all questions right



Move on to another topic when you have all three ticks

Extracting metals



Iron and steels



Aluminium and titanium



Extracting copper



Useful metals



Metallic issues

