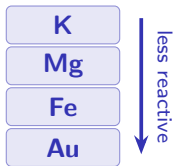


# Metals

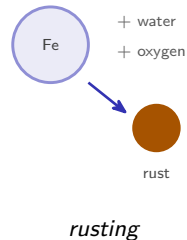
## IGCSE Chemistry ■ Topic 9

### IGCSE Chemistry



# What we will cover

- 1 Properties & uses
- 2 Alloys
- 3 The reactivity series
- 4 Rusting & its prevention
- 5 Extraction of metals
- 6 The blast furnace





# Properties and uses

## metals

good conductors; **malleable**  
& **ductile** ; high melting points

## non-metals

poor conductors; **brittle** ; low melting points

Uses follow properties: **aluminium** is light (aircraft, cables); **copper** conducts & is ductile (wiring).



*Aluminium is light and resists corrosion*

# The physical properties that decide a metal's use

## electrical conductivity

metals: **good**. Non-metals: poor, **except** graphite

## melting and boiling point

metals: usually **high**. Non-metals: usually low

## malleability and ductility

metals can be hammered into shape and drawn into wires

## copper

electrical wiring – good conductivity *and* ductility, so it can be drawn into wire

## aluminium

aircraft and drinks cans – low density and corrosion-resistant

## alloys

harder than the pure metal, because different-sized atoms stop the layers sliding

Give the property **and** the use it explains. “Copper conducts” is half a mark; “so it is drawn into wiring” completes it.

# Why metals behave as they do

## Conduction

Delocalised electrons move freely, giving high electrical and **thermal conductivity**.

## Malleable

Layers of ions slide over each other without breaking the metallic bond – so metals bend rather than shatter.

## With acids

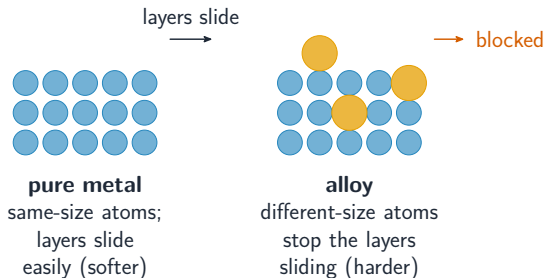
A reactive metal reacts with **acids** to give a **salt** and hydrogen – the fizz test.

## A useful oxide

**Calcium oxide** (from limestone in the blast furnace) removes acidic impurities as slag.

Every metallic property traces back to one picture: positive ions in a sea of delocalised electrons.

# Alloys



- **Brass** is a mixture of copper and **zinc** .
- **Stainless steel** is a mixture of **iron** with other elements such as **chromium** , **nickel** and **carbon** .



# The reactivity series

most  
reactive

|    |                    |
|----|--------------------|
| K  | potassium          |
| Na | sodium             |
| Ca | calcium            |
| Mg | magnesium          |
| Al | aluminium          |
| C  | carbon (non-metal) |

above carbon:  
extract by  
**electrolysis**

|    |                      |
|----|----------------------|
| Zn | zinc                 |
| Fe | iron                 |
| H  | hydrogen (non-metal) |
| Cu | copper               |
| Ag | silver               |
| Au | gold                 |

below carbon:  
extract by  
**reduction  
with carbon**

least  
reactive

- potassium, sodium and calcium react with cold water.
- magnesium reacts with steam (but only very slowly with cold water).
- magnesium, zinc and iron react with dilute hydrochloric acid; copper, silver and gold do not.

# Displacement and aluminium

## displacement

a more reactive metal  
pushes out a less reactive  
one (zinc displaces copper)

## aluminium

a tough **oxide layer** makes  
it seem less reactive than it is



*Rusting is a costly form of corrosion*

# Extracting aluminium by electrolysis

## The ore

Aluminium comes from **bauxite** , which is purified to aluminium oxide.

## Why electrolysis

Aluminium is above carbon in the reactivity series, so carbon cannot displace it – a **displacement reaction** will not work.

## Cryolite

The oxide melts at over 2000 °C, so it is dissolved in molten **cryolite** to lower the working temperature and save energy.

## At the electrodes

At the **cathode** ,  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ : gain of **electrons** , so **reduction** . At the **anode** , oxide ions lose electrons and the carbon burns away as **carbon dioxide** .

Reduction is gain of electrons – and the cathode is where the positive ions go, which is how to remember which is which.

## Displacement: what you would actually see

**the reaction**

$\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$  – a more reactive metal displaces a less reactive one

**observation**

a **pink-brown solid** coats the zinc – that is the displaced copper

**observation**

the grey zinc **dissolves** and gets smaller

**observation**

the blue solution **fades**, as copper ions leave it

**metal and acid**

**effervescence** as hydrogen escapes, and the **solid dissolves**

**aluminium's puzzle**

it seems less reactive than its position suggests, because a thin, strong **oxide layer** covers it and stops the reaction

Observations are **separate marks** from the equation. Say what changes colour, what dissolves, and what appears.



# Rusting

**Rusting** needs **both** water and oxygen.

The nail rusts only in the tube with both – rust is hydrated iron(III) oxide.

rusts



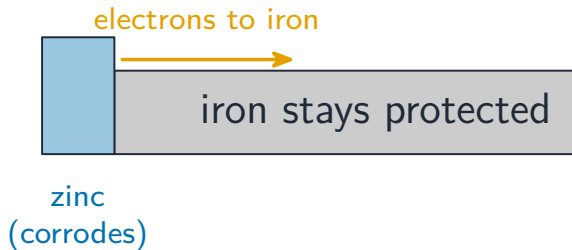
no rust



no rust



# Preventing rust



- **barrier** – paint, grease, plastic

- **galvanising** – a zinc coat

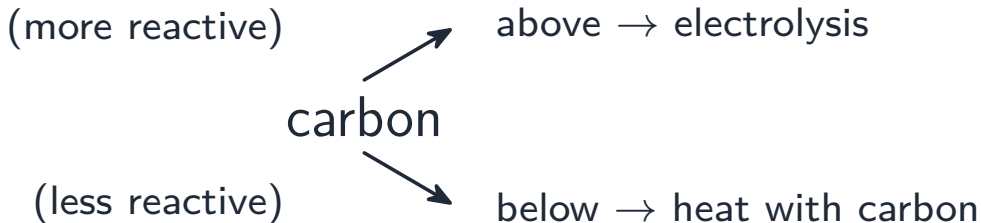
Zinc gives **sacrificial protection** : being more reactive, it corrodes **instead** of the iron.



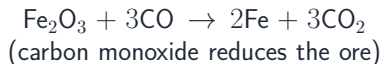
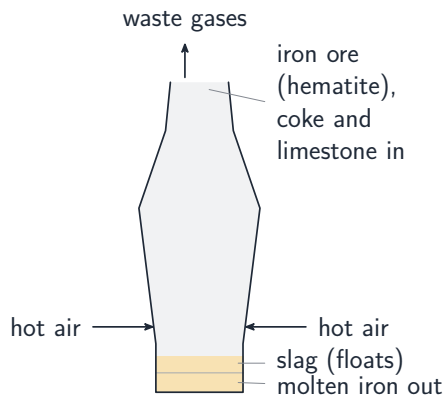
## Extraction: reactivity decides

How a metal leaves its **ore** depends on its reactivity:

- above carbon → **electrolysis** (aluminium)
- below carbon → heat with carbon (iron)



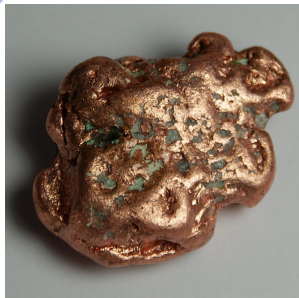
# The blast furnace



Iron from **hematite** :

- coke burns  $\rightarrow \text{CO}_2 \rightarrow$  **carbon monoxide**
- CO **reduces** the iron oxide to iron
- **limestone** removes sandy impurities as **slag**

## Chemical properties



Native copper: metals are shiny, dense, malleable conductors of heat and electricity

# Corrosion of metals



Corrosion slowly eats away unprotected metal.

## Exam tips

- Learn the **reactivity series** (potassium  $\rightarrow$  gold). A more reactive metal displaces a less reactive one from a solution of its ions.
- Metals *above* carbon are extracted by **electrolysis**; those *below* carbon (like iron) can be extracted by heating with carbon.
- **Rusting** needs *both* water and oxygen. Barrier methods (paint, oil) keep them out; **galvanising** also gives sacrificial protection, because the more reactive zinc corrodes instead of the iron.
- **Alloys** are harder than pure metals because the different-sized atoms stop the layers of ions sliding over each other.



## Worked example – which extraction method?

**Iron is extracted with carbon but aluminium needs electrolysis. Explain.**

- The method depends on the metal's place in the **reactivity series**.
- Iron is **below carbon**, so carbon can **reduce** its oxide in a blast furnace – cheap.
- Aluminium is **above carbon**, so carbon cannot take its oxygen away.
- Only **electrolysis** is powerful enough – which is why aluminium is expensive.

Above carbon  $\Rightarrow$  **elec-trolysis**. Below carbon  $\Rightarrow$  **reduce with carbon**. Un-reactive (gold)  $\Rightarrow$  found **native**, just dig it up.

## Topic 9 – key takeaways

1

### Alloys

harder – mixed atom sizes block sliding

2

### Reactivity

order of forming positive ions

3

### Rust

needs water + oxygen; zinc protects

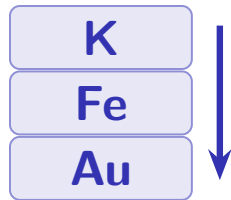
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### Extraction

above carbon: electrolysis; below: carbon

## Check yourself

- 1 Why is an alloy harder than a pure metal?
- 2 What two things are needed for iron to rust?
- 3 How does zinc protect iron even when scratched?
- 4 How is a metal above carbon extracted?



**Answers** 1. different-sized atoms block sliding layers 2. water and oxygen 3. it corrodes sacrificially instead 4. by electrolysis