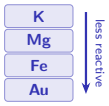
Metals

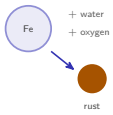
IGCSE Chemistry ▪ Topic 9

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



rusting

1 Properties

Properties and uses

metals	**non-metals**
good conductors; **malleable** 有展性 & **ductile** 有延性; high melting points	poor conductors; **brittle** 易碎; low melting points

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

Aluminium is light and resists corrosion

The physical properties that decide a metal's use

electrical conductivity 导电性	metals: good. Non-metals: poor, except graphite
melting and boiling point	metals: usually high. Non-metals: usually low
malleability 可锻性 and ductility 延展性	metals can be hammered into shape and drawn into wires
copper 铜	electrical wiring – good conductivity *and* ductility, so it can be drawn into wire
aluminium	aircraft and drinks cans – low density and corrosion-resistant
alloys 合金	harder than the pure metal, because different-sized atoms stop the layers sliding

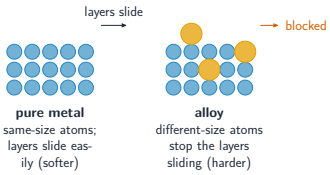
Give the property and the use it explains. "Copper conducts" is half a mark; "so it is drawn into wiring" completes it.

Why metals behave as they do

Conduction	Delocalised electrons move freely, giving high electrical and **thermal conductivity** 导热性.
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** 酸 to give a **salt** 盐 and hydrogen – the fizz test.
A useful oxide	**Calcium oxide** 氧化钙 (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** 黄铜 is a mixture of copper and **zinc** 锌.
- **Stainless steel** 不锈钢 is a mixture of **iron** 铁 with other elements such as **chromium** 铬, **nickel** 镍 and **carbon** 碳.

2 Reactivity

The reactivity series

most reactive

K	potassium	above carbon: extract by **electrolysis**
Na	sodium	
Ca	calcium	
Mg	magnesium	
Al	aluminium	
C	carbon (non-metal)	
Zn	zinc	below carbon: extract by **reduction with carbon**
Fe	iron	
H	hydrogen (non-metal)	
Cu	copper	
Ag	silver	
Au	gold	

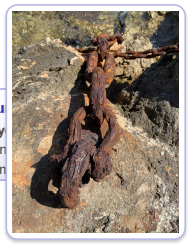
least reactive

- 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 置换反应
a more reactive metal pushes out a less reactive one (zinc displaces copper)

aluminiu
a tough **oxide lay**
makes it seen
reactive than



Rusting is a costly form of corrosion

Extracting aluminium by electrolysis

The ore	Aluminium comes from **bauxite** 铝土矿, which is purified to aluminium oxide.
Why electrolysis	Aluminium is above carbon in the reactivity series, so carbon cannot displace it – a **displacement reaction** 置换反应 will not work.
Cryolite	The oxide melts at over 2000 °C, so it is dissolved in molten **cryolite** 冰晶石 to lower the working temperature and save energy.
At the electrodes	At the **cathode** 阴极, $Al^{3+} + 3e^- \rightarrow Al$: gain of **electrons** 电子, so **reduction** 还原. At the **anode** 阳极, oxide ions lose electrons and the carbon burns away as **carbon dioxide** 二氧化碳.

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	$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$ – 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** 泡腾 as hydrogen escapes, and the solid dissolves
aluminium's puzzle	it seems less reactive than its position suggests, because a thin, strong **oxide layer** 氧化层 covers it and stops the reaction

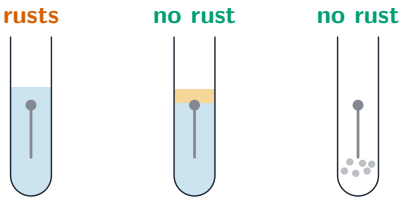
Observations are separate marks from the equation. Say what changes colour, what dissolves, and what appears.

3 Corrosion

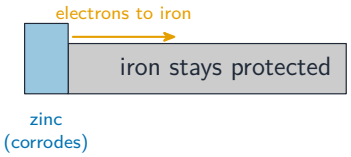
Rusting

Rusting 生锈 needs both water and oxygen.

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



Preventing rust



- **barrier** 隔离法 – paint, grease, plastic
- **galvanising** 镀锌 – a zinc coat

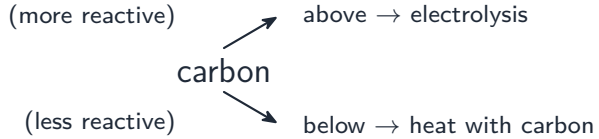
Zinc gives **sacrificial protection** 牺牲保护: being more reactive, it corrodes instead of the iron.

4 Extraction

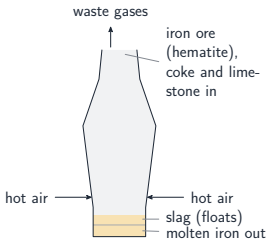
Extraction: reactivity decides

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

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



The blast furnace



$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
(carbon monoxide reduces the ore)

Iron from **hematite** 赤铁矿:

- coke burns → CO_2 → **carbon monoxide** 一氧化碳
- CO **reduces** 还原 the iron oxide to iron
- **limestone** 石灰石 removes sandy impurities as **slag** 炉渣

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 → 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.

5 Recap

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.

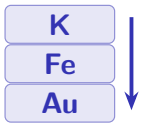
Above carbon ⇒ electrolysis. Below carbon ⇒ reduce with carbon. Unreactive (gold) ⇒ found native, just dig it up.

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
4. **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