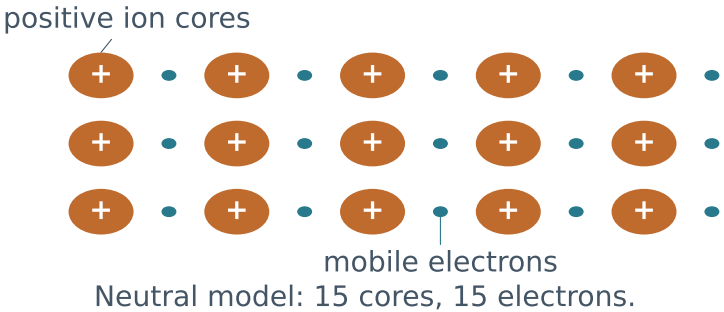
The metallic model

Structure 2.3 · SL and AHL

Why can a copper wire bend and conduct?



Mobile electrons and cohesive metallic attraction explain conduction and deformability.

Cations in a sea of electrons

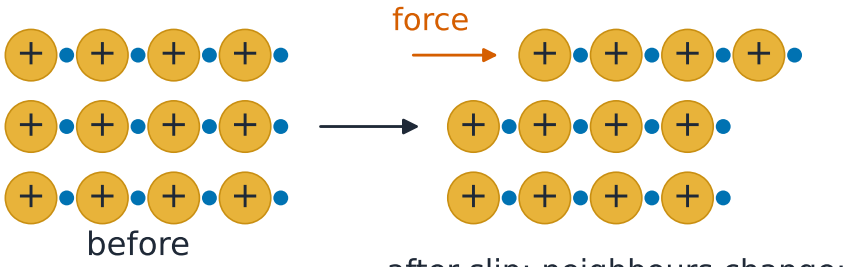
- Positive cores and extended electron **density** form one neutral solid.
- The cations sit in a **lattice**; the electrons are delocalized.
- There are no anions, and the bonding is **non-directional**.

> **Metallic bond** the electrostatic attraction between a lattice of cations and delocalized electrons

Each property from the model

Property	**Explanation**
electrical conductivity	delocalized electrons move when a voltage is applied
thermal conductivity	electrons pass kinetic energy quickly through the metal
malleability, ductility	layers slide; electrons move with them
high melting point	strong attraction in a giant lattice

Why metals bend instead of shattering

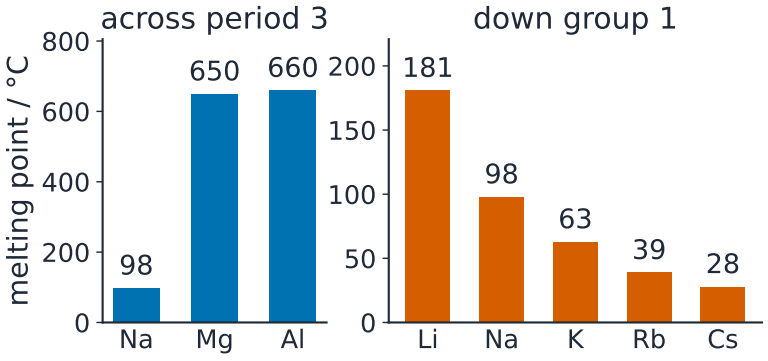


Non-directional metallic attraction can maintain cohesion during slip.

Metals against ionic compounds

	Metal	**Ionic compound**
particles	cations, electrons	cations, anions
solid conducts	yes, electrons	no, ions fixed
molten conducts	yes, electrons	yes, ions
a blow	layers slide, bends	like charges meet, shatters

Charge and size set the strength



Charge and size explain selected trends qualitatively; melting points also depend on structure.

Worked example: Mg against Na

1. **Given.** Supplied rounded melting points: Mg 650 °C; Na 98 °C. Explain the higher value for Mg using the metallic model.
2. **Structure.** Both have metallic cohesion; melting changes order but does not remove all interactions.
3. **Ions.** Mg^{2+} has a higher charge and is smaller than Na^{+}.
4. **Electrons.** Two delocalized electrons per Mg atom, one per Na atom.

Decision

Stronger attraction in magnesium, so more energy is needed to melt it.

Check: the metallic bond trend

Your turn

Which group 1 metal has the lowest melting point?

A. lithium
B. sodium
C. potassium
D. caesium

AHL: Transition metals use d electrons

Metal	Block	Melting point / °C
potassium	s	63
calcium	s	842
iron	d	1538
chromium	d	1907

Use the evidence

Zinc, with a full 3d sublevel, melts at only 420 °C.

Exam tips

> Always name the mobile charge carrier when explaining conduction.

- Metallic bond: cations and delocalized electrons; never anions.
- Metals conduct by electrons; molten ionic compounds by ions.
- **Malleability**: layers slide, **non-directional** bonding kept.
- Compare charge, then radius, and link to energy needed.

Melting and boiling are not ionization

Melting / vaporization

Liquid metal retains nearby interacting cores and mobile electrons.

Ordinary vapour is predominantly neutral atoms in the simple model.

Ionization

Removing electrons from gaseous atoms needs a separate energy input.

It is not implied by a boiling-point measurement.

Choose a property for its use

Use	Useful property	Why / constraint
wire	conduction + **ductility**	mobile electrons; suitable thickness and insulation
pan base	thermal conduction	energy transfer; chemical stability and safe handle
shaped sheet	**malleability**	cohesion during slip; thickness and microstructure

Worked: compare controlled electrical data

1. **A.** Invented equal-size samples at common temperature: 1.5 V gives $I_A = 0.30$ A, so $R_A = 5.0\ \Omega$.
2. **B.** At the same 1.5 V, $I_B = 0.15$ A gives $R_B = 10\ \Omega$.
3. **Compare.** $R_A/R_B = 0.50$; control contacts and geometry.

Decision

The current ratio is not by itself an electron-count ratio.

AHL: Carrier number is only part of the explanation

> A useful qualitative model is not an exact universal ranking formula.

- d states can contribute to metallic cohesion and electronic conduction.
- Crystal structure and band filling affect cohesion; scattering affects conductivity.
- Do not assign aqueous Fe^{2+}/Fe^{3+} charges to a pure metal as a measured particle inventory.

Check yourself

Try these

Explain why solid copper conducts but solid copper(II) chloride does not.

Explain why aluminium has a higher boiling point than sodium.

Predict whether potassium or calcium melts higher, and why.

AHL. Explain why iron melts far higher than calcium.