Metals: Properties and Reactivity

Matthew Williams • Chemistry • May 15, 2026

Metals: Properties and Reactivity

The reactivity of a metal determines how it behaves chemically and what it can be used for. All of a metal's physical properties flow from one structural feature — metallic bonding — and all of its chemical behaviour can be predicted from its position in the reactivity series.

Physical Properties of Metals

Most metals share a set of distinctive physical properties, all explained by metallic bonding (a lattice of positive metal ions surrounded by a sea of delocalised electrons):

Property	Explanation
Good electrical conductors	Delocalised electrons carry charge freely
Good thermal conductors	Delocalised electrons transfer kinetic energy rapidly
Malleable	Layers of ions slide without breaking the metallic bond
Ductile	Ions can rearrange without bonds breaking
Lustrous (shiny)	Delocalised electrons reflect light
High melting and boiling points	Strong metallic bonding requires much energy to overcome
Usually dense	Closely packed cations

Notable exceptions: mercury is a liquid metal at room temperature; sodium and potassium are soft, low-density, and low-melting because their metallic bonding is unusually weak.

Chemical Properties of Metals

Reactions with Oxygen

Metals react with oxygen to form metal oxides. More reactive metals react vigorously; less reactive metals react slowly or not at all.

$$2Mg + O_2 \rightarrow 2MgO \quad \text{(bright white flame)}$$

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3 \quad \text{(slow rusting)}$$

$$2Cu + O_2 \rightarrow 2CuO \quad \text{(slow; black coating)}$$

Gold does not react with oxygen.

Reactions with Water

Highly reactive metals react with cold water; moderately reactive metals react with steam; unreactive metals do not react with water at all.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2 \quad \text{(vigorous, floats, fizzes)}$$

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2 \quad \text{(steady fizzing)}$$

$$Mg + H_2O(g) \rightarrow MgO + H_2 \quad \text{(steam only)}$$

Reactions with Dilute Acids

Metals above hydrogen in the reactivity series displace hydrogen from dilute acids:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

Copper, silver, and gold do not react with dilute acids.

Reactions of Metallic Compounds

Metals also form compounds that decompose on heating. Less reactive metals' compounds break down more easily, and the products follow a pattern that depends on position in the reactivity series.

Thermal Decomposition of Carbonates

Metal carbonates decompose on heating to give the metal oxide and CO, Less reactive metals' carbonates decompose more easily:

$$\mathrm{CaCO_3} \rightarrow \mathrm{CaO} + \mathrm{CO_2} \quad \textbf{(needs strong heat)}$$

$$\mathrm{CuCO_3} \rightarrow \mathrm{CuO} + \mathrm{CO_2} \quad \textbf{(green} \rightarrow \textbf{black)}$$

Sodium and potassium carbonates do not decompose at Bunsen burner temperatures.

Thermal Decomposition of Nitrates

Metal	Products of heating nitrate
K, Na	Metal nitrite + oxygen: 2KNO$_3$ → 2KNO$_2$ + O$_2$
Ca, Mg, Al, Zn, Fe, Pb, Cu	Metal oxide + NO$_2$ + oxygen: 2Cu(NO$_3$)$_2$ → 2CuO + 4NO$_2$ + O$_2$
Ag, Au	Metal + NO$_2$ + oxygen: 2AgNO$_3$ → 2Ag + 2NO$_2$ + O$_2$

Thermal Decomposition of Hydroxides

Most metal hydroxides decompose on heating to give the oxide and water:

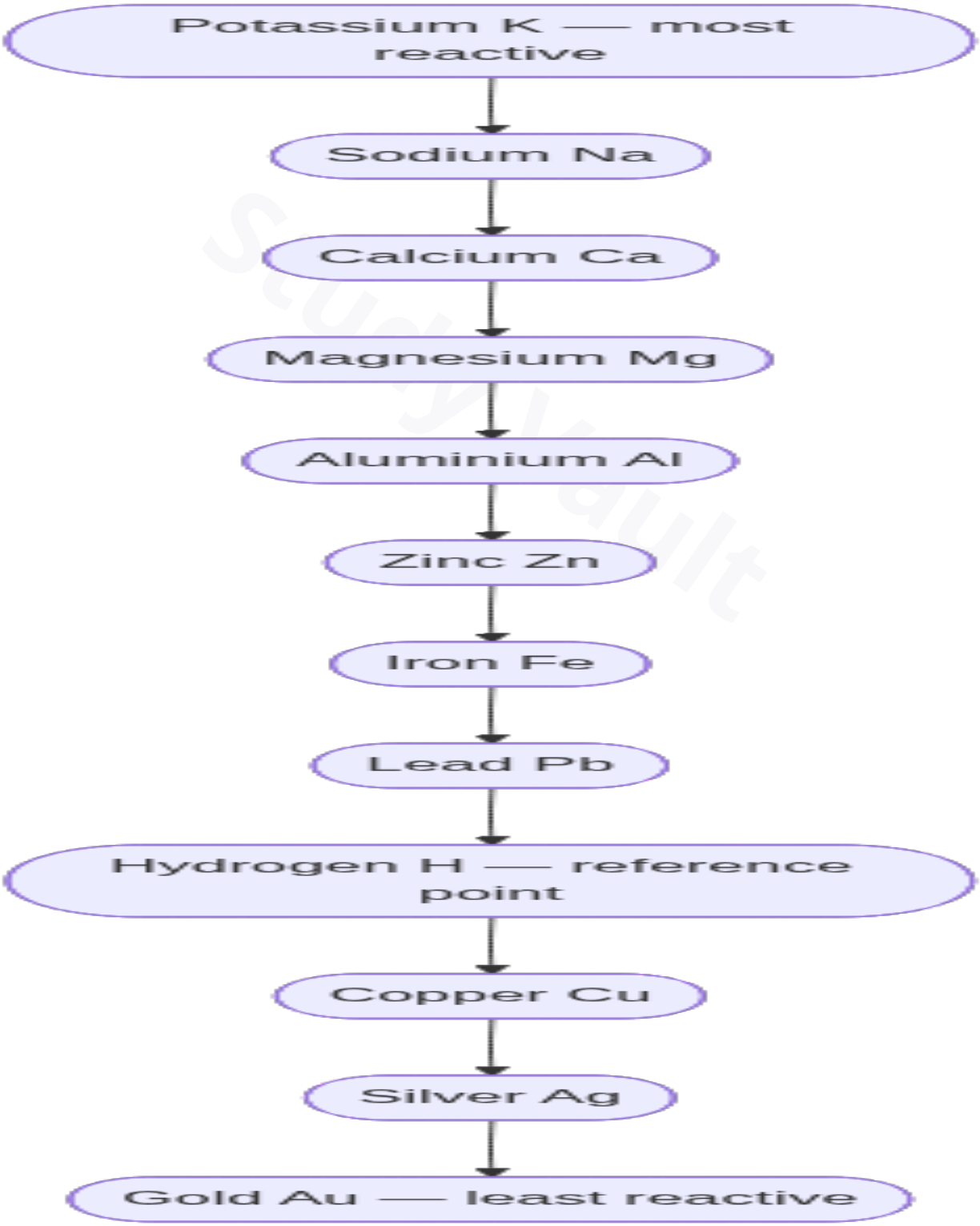
$$\mathrm{Cu(OH)_2} \rightarrow \mathrm{CuO} + \mathrm{H_2O} \quad \textbf{(blue} \rightarrow \textbf{black)}$$

NaOH and KOH are stable to heat and do not decompose at lab temperatures.

The Reactivity Series

The patterns across all the reactions above fall into the same order. The reactivity series makes that order explicit.

The reactivity series ranks metals (and hydrogen) in order of how readily they lose electrons. Metals at the top are most reactive.



Reactivity series

Using the series, you can predict:

- Whether a metal reacts with water or acid
- Which metal displaces another in a displacement reaction
- What method of extraction is needed

Displacement Reactions

The series also predicts reactions that haven't been observed yet. If a more reactive metal is placed in a solution of a less reactive metal's salt, it displaces it.

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

$$\mathrm{Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)}$$

Observations: blue solution fades; reddish-brown copper deposits on the zinc; zinc dissolves.

Net ionic equation: $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ (zinc is oxidised; copper ions are reduced)

$$\mathrm{Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)}$$

Observations: blue solution turns pale green; copper deposited.

If the added metal is less reactive than the metal in solution, no reaction occurs. For example, copper placed in zinc sulfate solution produces no change.