The reactivity series

4.4.1.2 · Chemical changes · revision notes

How metals are ranked by how readily they react, how this links to forming positive ions, and how a more reactive metal displaces a less reactive one. Questions often give observations from an experiment and ask you to put metals in order or predict whether a reaction happens.

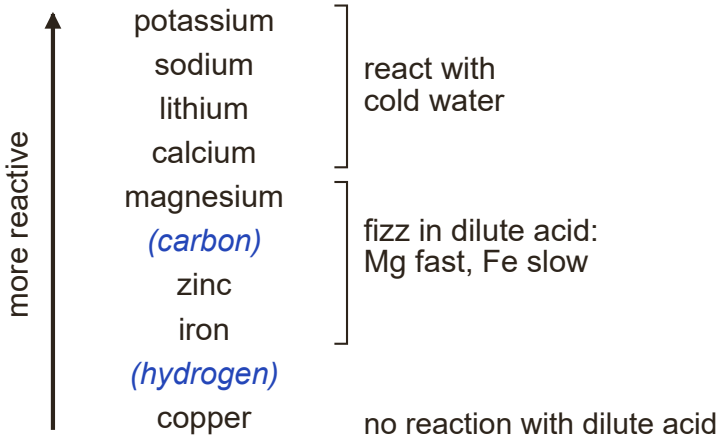
Key facts

- K > Na > Li > Ca > Mg > C > Zn > Fe > H > Cu
- metal + acid → salt + hydrogen
- Reactivity = tendency of a metal to form its positive ion
- Hydrogen test: lit splint → squeaky pop
- metal + water → metal hydroxide + hydrogen
- A more reactive metal displaces a less reactive metal from its compound
- Copper does not react with water or with dilute hydrochloric or sulfuric acid

Notes

The reactivity series

- Metals can be put in order of reactivity. The order you need, most reactive first: **potassium, sodium, lithium, calcium, magnesium, zinc, iron, copper**.
- The non-metals **carbon** and **hydrogen** are often included: carbon goes between magnesium and zinc, and hydrogen goes between iron and copper.



Most reactive at the top. Carbon and hydrogen (blue) are non-metals placed in the series for comparison.

- When metals react, their atoms lose electrons and form **positive ions**. The more easily a metal forms its positive ion, the more reactive it is.

Reactions with water and dilute acids

- Potassium, sodium and lithium react with cold water, fizzing and moving about on the surface: metal + water → metal hydroxide + hydrogen. Potassium reacts vigorously and a lilac flame is seen.
- Calcium reacts steadily with cold water. Magnesium reacts only very slowly with cold water. Zinc, iron and copper show no visible reaction with cold water.
- With dilute acids: metal + acid → salt + hydrogen. Magnesium fizzes quickly, zinc steadily and iron slowly. Copper does not react with dilute hydrochloric or sulfuric acid.
- Calcium reacts very vigorously with dilute acids. Potassium, sodium and lithium react dangerously fast with acids, so these reactions are not done in school.
- Test for hydrogen: a lit splint gives a squeaky pop.

Displacement reactions

- A more reactive metal **displaces** a less reactive metal from its compound, e.g. from a solution of its salt.
- Example: magnesium + copper sulfate → magnesium sulfate + copper. The blue colour fades, a pink-brown coating of copper forms and the mixture gets warmer.
- If the metal added is less reactive, nothing happens, e.g. copper + zinc sulfate: no reaction.
- You can find an order of reactivity by adding each metal to solutions of the other metals' salts and seeing which ones react.
- Or add the same mass of each metal powder to the same volume and concentration of copper sulfate solution and measure the temperature rise. The bigger the rise, the more reactive the metal.

Why some metals are more reactive Grade 7+ only

- Reactivity depends on how easily a metal atom loses its outer electrons. Potassium loses its outer electron very easily, so it reacts vigorously; copper does not form ions easily, so it is unreactive. Grade 7+ only
- In a displacement reaction, atoms of the more reactive metal lose electrons and become ions, while ions of the less reactive metal gain electrons and become atoms. Grade 7+ only

How to answer each type of question

Put metals in order of reactivity from results

1 to 3 marks | Grade 4

1. Find the measure of how vigorous each reaction was: bubbles, time to disappear, temperature rise.
2. More vigorous means more reactive.
3. Write the order in the direction the question asks (most or least reactive first).

Example. A student added equal-sized pieces of four metals, W, X, Y and Z, to dilute hydrochloric acid.

Metal	Observation
W	steady fizzing
X	no bubbles
Y	very rapid fizzing
Z	a few slow bubbles

(a) Put the metals in order of reactivity, most reactive first.
(b) Which metal could be copper? Give a reason.

Model answer.

(a) Y, W, Z, X (1)

(b) X (1) because copper does not react with dilute hydrochloric acid / copper is less reactive than hydrogen (1)

Describe the reaction of a metal with water

2 to 3 marks | Grade 4

1. Give what you would see: fizzing, floating, moving, melting, getting smaller.
2. Name both products: the metal hydroxide and hydrogen.

Example. A small piece of sodium is added to a trough of water.
Describe what you would see and name the products.

Model answer.

Fizzing / bubbles (1)

Floats and moves around / melts into a ball / gets smaller and disappears (1)

Products: sodium hydroxide and hydrogen (1)

Predict and explain a displacement reaction

2 to 4 marks | Grade 5

1. Find both metals in the reactivity series.
2. If the solid metal is more reactive than the metal in the compound, it displaces it.
3. Name the products; if it is less reactive, say 'no reaction' and give the reason.

Example. A piece of zinc is placed in blue copper sulfate solution.
(a) Explain why a reaction happens.
(b) Write a word equation for the reaction.
(c) Predict what happens when copper is placed in zinc sulfate solution.

Model answer.

(a) Zinc is more reactive than copper (1) so zinc displaces copper from copper sulfate (1)
(b) zinc + copper sulfate → zinc sulfate + copper (1)
(c) No reaction, because copper is less reactive than zinc (1)

Explain reactivity in terms of ions

2 marks | Grade 7

1. Say that metal atoms lose electrons to form positive ions when they react.
2. Say that the more reactive metal forms positive ions more easily.

Example. Potassium reacts much more vigorously with water than magnesium does.
Explain why, in terms of ions.

Model answer.

When metals react, their atoms lose (outer) electrons to form positive ions (1)
Potassium atoms form positive ions more easily than magnesium atoms (1)

Don’t lose marks

- Putting lithium above sodium or potassium.
- Saying copper reacts with dilute acid to give hydrogen.
- Giving the metal oxide as the product with cold water: it is the metal hydroxide.
- Writing 'hydrogen is produced' when asked what you would see: say 'fizzing' or 'bubbles'.
- Predicting a displacement when the metal added is less reactive than the metal in the compound.

More tips

Memory tricks

- Mnemonic for the order: Please Send Lions, Cats, Monkeys, Cute Zebras In Hot Countries (K, Na, Li, Ca, Mg, C, Zn, Fe, H, Cu).
- Reactivity increases down Group 1, so potassium > sodium > lithium.
- Displacement: the more reactive metal 'steals' the other metal's partner in the compound.
- Anything below hydrogen (copper here) does not give hydrogen with dilute acids.

Exam technique

- 'Describe what you would see' means observations: bubbles, the metal disappearing, colour changes, getting warm.
- When you deduce an order, quote the evidence, e.g. 'Y gave the most bubbles'.
- For a fair comparison, keep the size of metal pieces, the acid concentration and volume, and the temperature the same.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Recall the order of the reactivity series**
Potassium, sodium, lithium, calcium, magnesium, (carbon), zinc, iron, (hydrogen), copper, from most to least reactive.

Grade 4 — **Describe metal reactions with water and acid**
Say what you would see, e.g. fizzing, and name the products (metal hydroxide or salt, plus hydrogen).

Grade 5 — **Deduce an order of reactivity from results**
The more vigorous the reaction (more bubbles, bigger temperature rise), the more reactive the metal.

Grade 5 — **Predict whether a displacement reaction happens**
A metal displaces another metal from its compound only if it is more reactive.

Grade 6 — **Write equations for displacement reactions**
For example, zinc + copper sulfate → zinc sulfate + copper.

Grade 7 — **Link reactivity to forming positive ions**
The more easily a metal's atoms lose electrons to form positive ions, the more reactive the metal is.

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