Reactions of acids with metals

4.4.2.1 · Chemical changes · revision notes

Acids react with some metals to produce a salt and hydrogen. You need the reactions of magnesium, zinc and iron with hydrochloric and sulfuric acids, and at Higher tier you must explain them as redox reactions in terms of electrons.

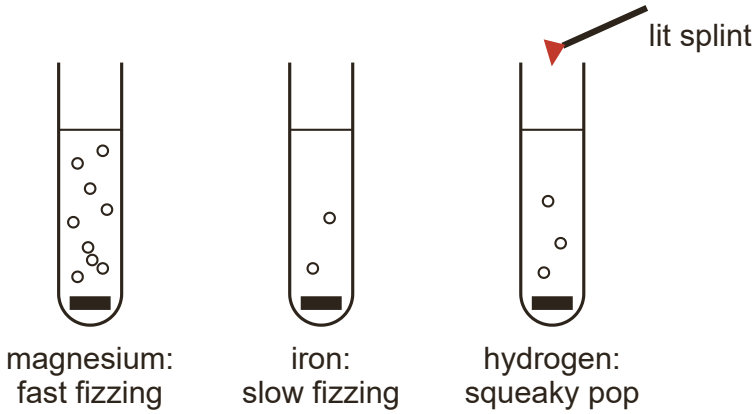
Key facts

- metal + acid → salt + hydrogen
- $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$
- Grade 7+ only Ionic equation: $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$
- Hydrochloric acid → chlorides; sulfuric acid → sulfates
- $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
- Hydrogen test: lit splint → squeaky pop

Notes

Metal + acid

- Acids react with some metals: **metal + acid → salt + hydrogen**.
- You need the reactions of **magnesium, zinc and iron** with dilute **hydrochloric acid** and dilute **sulfuric acid**.
- You see fizzing (bubbles of hydrogen), the metal gets smaller and the mixture gets warmer. Magnesium reacts quickly, zinc steadily and iron slowly. Copper does not react with these acids.



Same acid, same size of metal: more bubbles per second means a more reactive metal.

- Test for hydrogen: hold a lit splint at the mouth of the test tube. Hydrogen burns with a **squeaky pop**.

Naming salts and writing equations

- Hydrochloric acid (HCl) makes **chlorides**. Sulfuric acid (H_2SO_4) makes **sulfates**.
- $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
- $Fe + 2HCl \rightarrow FeCl_2 + H_2$ (iron forms iron(II) chloride with dilute hydrochloric acid)
- Hydrogen is a diatomic gas, so it is always written H_2.

A redox reaction (in terms of electrons) Grade 7+ only

- Acids contain hydrogen ions, H^+. The chloride or sulfate ions do not change, so they are spectator ions and are left out of the ionic equation. Grade 7+ only
- Ionic equation: $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ Grade 7+ only
- Magnesium atoms lose electrons: $Mg \rightarrow Mg^{2+} + 2e^-$. Magnesium is **oxidised**. Grade 7+ only
- Hydrogen ions gain electrons: $2H^+ + 2e^- \rightarrow H_2$. Hydrogen ions are **reduced**. Grade 7+ only
- Zinc and iron react in the same way: $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ and $Fe + 2H^+ \rightarrow Fe^{2+} + H_2$. Grade 7+ only

How to answer each type of question

Complete a word equation

1 to 2 marks | Grade 3

1. The products are always a salt and hydrogen.
2. Name the salt: metal name first, then chloride (hydrochloric acid) or sulfate (sulfuric acid).

Example. Complete the word equation.
zinc + hydrochloric acid → ..... + ...

Model answer. zinc chloride (1) + hydrogen (1)

Describe how to compare the reactivity of two metals with acid

3 to 4 marks | Grade 5

1. Use the same mass or size of each metal.
2. Use the same volume and concentration of acid at the same temperature.
3. Say what you measure: volume of gas in a set time, rate of bubbling or temperature rise.
4. Say how you decide: the faster reaction shows the more reactive metal.

Example. Describe how a student could show that magnesium is more reactive than iron, using dilute sulfuric acid.

Model answer.

Add the same mass / same size pieces of each metal (1) to the same volume and concentration of sulfuric acid (1)

Measure the volume of hydrogen made in a set time / compare the rate of bubbling (1)

Magnesium produces gas faster, so it is more reactive (1)

Write a balanced symbol equation

2 marks | Grade 6

1. Work out the formula of the salt from the ion charges (Fe^{2+} and Cl^- give $FeCl_2$).
2. Write hydrogen as H_2.
3. Balance, then check every element.

Example. Iron reacts with dilute hydrochloric acid to form iron(II) chloride, $FeCl_2$, and hydrogen. Write a balanced symbol equation for this reaction.

Model answer.

Correct formulae: $Fe + HCl \rightarrow FeCl_2 + H_2$ (1)

Balanced: $Fe + 2HCl \rightarrow FeCl_2 + H_2$ (1)

Explain, in terms of electrons, why the reaction is redox

2 marks | Grade 7

1. Use the ionic equation (spectator ions left out).
2. Say which species loses electrons (oxidised) and which gains electrons (reduced).
3. Half equations can support your answer.

Example. Zinc reacts with dilute sulfuric acid:
$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$
Explain, in terms of electrons, why this is a redox reaction.

Model answer.

Zinc atoms lose electrons / $Zn \rightarrow Zn^{2+} + 2e^-$, so zinc is oxidised (1)

Hydrogen ions gain electrons / $2H^+ + 2e^- \rightarrow H_2$, so hydrogen ions are reduced (1)

Don’t lose marks

- Writing hydrogen as H instead of H_2.
- Naming salts wrongly, e.g. 'zinc hydrochloride' instead of zinc chloride.
- Saying copper reacts with dilute acid to give hydrogen.
- Saying hydrogen ions are oxidised: they gain electrons, so they are reduced.
- Mixing up the hydrogen test (lit splint, pop) with the oxygen test (glowing splint relights).

More tips

Memory tricks

- MASH: Metal + Acid → Salt + Hydrogen.
- Salt name = metal name + ending from the acid (hydrochloric → chloride, sulfuric → sulfate).
- Squeaky pop = hydrogen. A glowing splint relighting is the test for oxygen, not hydrogen.

Exam technique

- For observations, write 'fizzing' or 'bubbles'. 'Hydrogen is produced' is not an observation.
- Higher tier: name the particles in redox answers: 'magnesium atoms lose electrons', 'hydrogen ions gain electrons'.
- In practical comparisons, say what you keep the same as well as what you measure.

What each grade needs

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

Grade 3 — **Name the products of metal + acid**
A salt and hydrogen, e.g. magnesium + hydrochloric acid → magnesium chloride + hydrogen.

Grade 4 — **Name the salt from the acid used**
Hydrochloric acid gives chlorides and sulfuric acid gives sulfates.

Grade 4 — **Describe the test for hydrogen**
A lit splint held at the mouth of the tube burns the hydrogen with a squeaky pop.

Grade 6 — **Write balanced symbol equations for these reactions**
For example, $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$.

Grade 7 — **Explain these reactions as redox reactions**
The metal atoms lose electrons (oxidised) and the hydrogen ions gain electrons (reduced).

Grade 8 — **Write ionic and half equations for them**
For example, $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$, with the acid's negative ion left out as a spectator.

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