Metals with dilute acids

Hydrochloric acid AND sulfuric acid • Core Practical 2.21

YEAR 10 / LESSON 28 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

How do the reactions of magnesium, zinc, iron and copper with dilute hydrochloric acid and with dilute sulfuric acid compare, and what order of reactivity does that support?

Metals that react with dilute acid produce a salt and hydrogen gas; some metals do not react at a rate you can see. In this investigation you add small, cleaned pieces of magnesium, zinc, iron and copper to equal measured volumes of dilute hydrochloric acid and, separately, of dilute sulfuric acid. You compare the vigour of bubbling, any other visible change, and, where gas is clearly being produced, the teacher-demonstrated test for hydrogen. Use your observations to report an apparent, possibly incomplete order under the conditions used. This investigation does not include sodium, potassium or calcium, does not test aluminium, and does not investigate reactions with water. The full reactivity series in the specification includes metals you will not observe here.

Observed bubbling rate also depends on exposed surface area, surface condition and temperature. With unlike metal forms, report the apparent order under these conditions; it does not alone establish an intrinsic reactivity ranking. An incomplete or inconclusive order is an acceptable result.

Course links: 2.21 — the acid–metal investigation. 2.15 is covered only for these metals with acids, not water. 2.17 is the full recall list: this practical observes only Mg, Zn, Fe and Cu.

Safety throughout

Wear splash-resistant eye protection throughout. Dilute acids can irritate skin and eyes: wash splashes with plenty of water and tell the teacher; do not taste or sniff. Hydrogen is extremely flammable. The only flame is the lighted splint used as your teacher shows, at the mouth of a tube already producing gas, directed away from people and magnesium. Use only your issued magnesium; never try to burn it or take ribbon away. Sodium and potassium must not be put into acid. Report broken glass and wash hands.

Equipment • per group of up to three

Eye protection; rack and eight named test tubes, preferably 100 × 16 mm or similar; 10 cm^3 measuring cylinder; forceps; emery paper; issued Mg, Zn, Fe and Cu pieces; labelled 0.4 mol dm^{-3} HCl and 0.2 mol dm^{-3} H_2SO_4, about 25 cm^3 of each; labelled residue bowl. The teacher controls the splint-lighting flame and provides wood splints and two LOOSE bungs for the hydrogen test only.

Use 4.0 cm^3 measured acid per tube: an explicit local volume choice, NOT a conversion from a stated depth. Record the actual tube size. If the teacher uses a depth alternative, measure and record a consistent volume in that named tube rather than assuming it equals 4.0 cm^3.

Prepare the eight tubes

Record the actual metal forms; they are not matched surface areas

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Metal	Small form issued • record what you actually use
Magnesium	Ribbon, about 1.0 cm; one piece per acid, under supervision.
Zinc	One small granule (up to about 5 mm) OR a piece of foil; record which.
Iron	Clean, uncoated filings, short nail or wire; not painted or galvanised.
Copper	Foil or turnings; record actual form and approximate size.

Observed bubbling rate also depends on exposed surface area, surface condition and temperature. With unlike metal forms, report the apparent order under these conditions; it does not alone establish an intrinsic reactivity ranking.

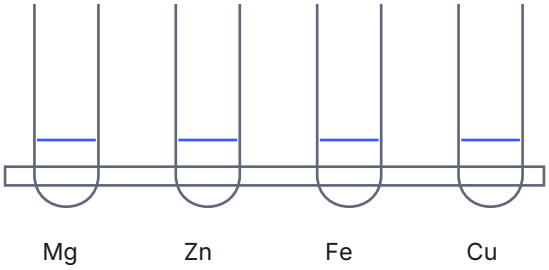
Method • preparation

1. Put on eye protection. Label eight tubes: Mg–HCl, Zn–HCl, Fe–HCl, Cu–HCl, Mg–H_2SO_4, Zn–H_2SO_4, Fe–H_2SO_4, Cu–H_2SO_4, and stand them in the rack.

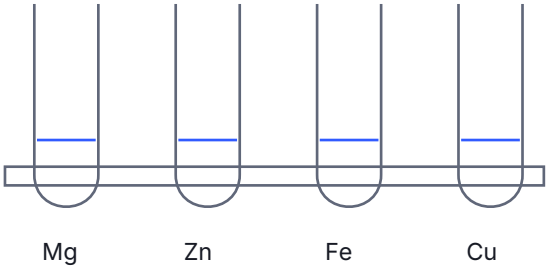
2. Clean each metal piece with emery paper until it is shiny. Handle pieces with forceps. Record the metal, the form (ribbon, granule, filings, foil, nail) and the approximate size.

3. Measure 4.0 cm^3 of 0.4 mol dm^{-3} hydrochloric acid into each of the four HCl tubes. Measure 4.0 cm^3 of 0.2 mol dm^{-3} sulfuric acid into each of the four H_2SO_4 tubes. This 4.0 cm^3 is the local measured-volume choice. If the teacher uses a depth alternative instead, do not assume that a stated depth equals 4.0 cm^3; measure a consistent volume in the named tube and write that volume down.

HCl • 0.4 mol dm^{-3}



H_2SO_4 • 0.2 mol dm^{-3}



Four metals × two acids = eight open tubes • 4.0 cm^3 measured per tube.

Schematic only: drawn liquid depth is not a conversion or an observed result.

Observe and test safely

Teacher demonstration first • local risk assessment decides student testing

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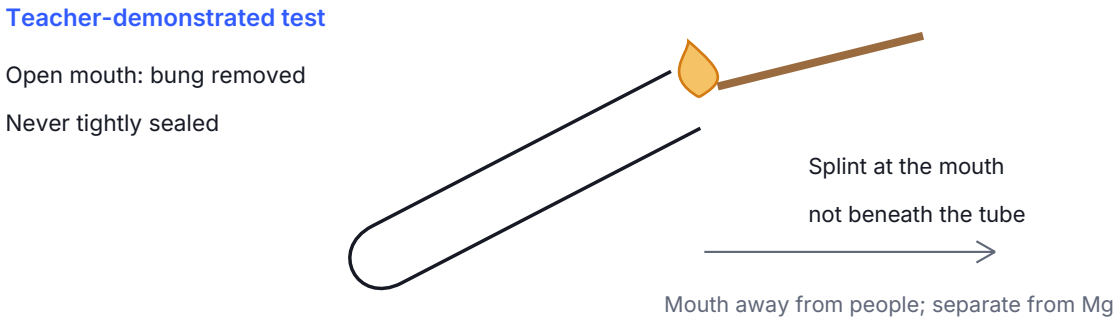
4. Working along one acid set at a time, add the matching metal piece to each tube. Do not add a second piece, and do not add magnesium to a flame.

5. Observe each tube for a few minutes, side by side. Record: whether bubbling starts, how the bubbling compares between metals in the same acid, whether the metal is visibly consumed, any colour change in the solution, and whether the tube feels warmer (a qualitative observation only — this is not a temperature-rise experiment, and no value in °C is required). Observed bubbling rate also depends on exposed surface area, surface condition and temperature. With unlike metal forms, report the apparent order under these conditions; it does not alone establish an intrinsic reactivity ranking. If the observations do not support a complete order, record an incomplete or inconclusive order.

6. Hydrogen test • only where gas is clearly produced

Your teacher first demonstrates the test. A loosely fitting bung may be used to let gas escape slowly. If a loosely fitting bung is used, remove it before bringing the lighted splint to the tube mouth. Never seal the reacting tube tightly.

Hold the lighted splint at the tube mouth, pointed away from people and kept well apart from magnesium. If your teacher permits you to test, test only clearly gas-producing tubes; do NOT test copper tubes. No other naked flame is used. If magnesium is reacting vigorously, wait until fizzing is not violent or ask the teacher to test. Whether you test or only watch is decided by the local risk assessment; this booklet does not replace it.



Only when gas is clearly produced; no test on copper. Schematic, not a result.

7. Cleanup

Decant each mixture into the labelled residue bowl, including any unreacted metal. Do not use the sink for solids. Return unused metal and leftover acid bottles to the teacher. Rinse and rack the tubes as directed. Wash hands.

Results • hydrochloric acid

Actual observations only • no expected bubbling scores or rank

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Actual tube size / measured volume if a teacher-directed depth alternative was used:

Metal	Form and approximate size	HCl volume / concentration	Actual observations: bubbling, appearance, qualitative warmth	Hydrogen test: done / watched / not done; actual result
Magnesium				
Zinc				
Iron				
Copper				

Record no visible change if that is what you observe. Do not turn a few initial bubbles into an assumed reaction. Qualitative warmth needs no numerical °C value.

Unclear / repeated observations and relevant surface or temperature conditions:

Results • sulfuric acid

Compare metals within the same acid before comparing the two sets

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Metal	Form and approximate size	H_2SO_4 volume / concentration	Actual observations: bubbling, appearance, qualitative warmth	Hydrogen test: done / watched / not done; actual result
Magnesium				
Zinc				
Iron				
Copper				

Observed bubbling rate also depends on exposed surface area, surface condition and temperature. With unlike metal forms, report the apparent order under these conditions; it does not alone establish an intrinsic reactivity ranking. An incomplete or inconclusive order is acceptable. These observations do not place untested metals or investigate reactions with water.

Unclear / repeated observations; any differences from the HCl conditions:

No graph is required. If your teacher defines a local bubbling score, it is a qualitative teaching aid, not a measured gas volume. Do not add predicted scores.

Explain and evaluate

Report an apparent, possibly incomplete order under your conditions

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1. Using only your observations, report the apparent order of magnesium, zinc, iron and copper with dilute hydrochloric acid under the conditions you used, or state that the order is incomplete or inconclusive. Do the sulfuric acid results support the same apparent order? Observed bubbling rate also depends on exposed surface area, surface condition and temperature. With unlike metal forms, report the apparent order under these conditions; it does not alone establish an intrinsic reactivity ranking.

2. Name the gas produced when a metal reacted, and describe the test and result you used (or that your teacher showed) to identify it.

3. Write a word equation, and a balanced symbol equation with state symbols, for magnesium with dilute hydrochloric acid, and for zinc with dilute sulfuric acid.

4. Why were sodium and potassium not tested with acid in this practical?

5. This practical does not include water, calcium or aluminium. Why can you not, from these results alone, write the full specification order of the eleven metals in 2.17?

6. Suggest one change that would make the comparison more quantitative (for example a gas volume in a fixed time). You are not required to carry out that change in this investigation.

Sources: Pearson Edexcel International GCSE Chemistry, Issue 3 (2024), 2.15 / 2.17 / 2.21; school Lesson 28 concentrations; RSC / Nuffield, Reactions of metals with acids producing salts (446), Lesson 1. The measured 4.0 cm^3 is a local choice, not a depth conversion.