Core practical: oxygen in air by rusting

Student activity • staff demonstration

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The question

What fraction of trapped air is removed as iron rusts?

Observe a staff-operated rusting experiment over several days. Use measured gas-volume loss to estimate oxygen, with pressure, temperature and incomplete reaction treated as limitations.

Equipment

- Eye protection for observers; booklet and calculator
- Staff: three 100 cm^3 graduated cylinders, secure clamps, deep water trough and thermometer
- Staff: clean uncoated iron wool, forceps, balance, deionised water and labels; no acid or flame

Wear eye protection while observing. Staff handle sharp iron fibres, wet glassware and clamps. Report breakage; do not move the cylinders. No flames, hot copper, phosphorus or accelerant acids are used.

Course coverage: Shared core: 2.9, 2.10 and 2.14. Iron-rusting demonstration with a later stable-volume reading. No heated copper or phosphorus procedure is used.

Plan, model or apparatus sketch

Sketch the inverted cylinder and label equal water levels before reading.

Method and reasoning

Read the whole sequence before starting

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1. Observe staff secure a small loose plug of damp iron wool at the closed end of each inverted cylinder over water. Do not handle fibres or move the apparatus. The mouth stays below water throughout.

2. At room temperature, staff adjust each cylinder so the inside and outside water surfaces are at the same height without admitting air. Read and record the initial trapped-gas volume and temperature.

3. Leave the labelled setups undisturbed. Record the time/date and actual volume at the planned follow-up; do not substitute a pre-prepared apparatus without clearly labelling it as a different run.

4. Repeat readings on later days until there is no further change within the graduation precision. Staff equalise water levels and compare at the same room temperature before each final reading.

5. Calculate percentage volume removed: (initial volume − final stable volume) ÷ initial volume × 100. Compare the three runs rather than forcing the answer to exactly 21%.

6. Explain why water rises, why the gas remaining is a mixture and why this is only an approximate oxygen estimate. Record any leak, temperature change or incomplete rusting.

Cleanup

- Keep labelled setups secured for the follow-up.
- After final readings, staff collect iron fibres for the local solid-waste route, rinse equipment and wash hands.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Dry-air syllabus approximations: nitrogen 78%, oxygen 21%, argon 0.9%, carbon dioxide about 0.04%; rounded values omit traces and water vapour. Invented calculation only: 80.0 cm³ initially and 63.5 cm³ finally. This method actually measures damp gas; water vapour, liquid/wool displacement and gas dissolution limit agreement with dry-air composition.

Run	Initial / cm³	Stable final / cm³	Removed / %
A			
B			
C			

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Calculate the percentage removed in the invented example, keeping it separate from your observations.

2. Why does the water rise as the iron rusts?

3. Why must water levels be equalised and temperatures comparable when reading gas volumes?

4. Why is a stable final volume more convincing than a reading after an arbitrary short time?

5. Is the remaining gas pure nitrogen? Explain using the dry-air composition.

6. Explain two reasons the measured fraction might differ from 21%, including the direction of an effect where justified.