Rusting: conditions and protection

Student activity • multi-day investigation

YEAR 10 / LESSON 31 / CHEMISTRY + SCIENCE (DOUBLE AWARD)

The question

What does iron need to rust, and how can we interrupt it?

Compare iron nails exposed to both air and water, water with oxygen access restricted, or dry air. Set up a several-day investigation and use a dated earlier set if available. Do not describe a prediction as an observation.

Equipment

- Eye protection; rack and three labelled prepared tubes A, B and C
- Matching clean iron nails; room-temperature water and teacher-prepared comparison tubes
- Labels, observation sheet and access to dated photographs or an earlier set

Wear eye protection; handle nails with care. Only cooled tubes reach pupils. Do not open desiccant tubes or touch drying agent. Keep tubes upright; report broken glass. Oil spills make surfaces slippery.

Course coverage: 2.18–2.19: conditions for rusting; barrier methods and sacrificial protection.

Plan, model or apparatus sketch

Sketch A: air + water; B: oil over boiled water; C: dry air.

Method and reasoning

Read the whole sequence before starting

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1. Wear eye protection. Check tube labels and record the initial appearance of each nail. Keep staff-prepared tubes B and C closed.

2. In A place a nail in a tube and add room-temperature water until half the nail is submerged; leave access to air.

3. Observe B: the teacher has submerged a nail in freshly boiled water and covered the surface with oil to restrict oxygen entry. The tube is cooled and stoppered before distribution.

4. Observe C: a dry nail is held above, not touching, a drying agent in a stoppered dry tube. Dry air is present, but water is restricted.

5. Stand the rack in the agreed location. Record date, time, position and appearance now and over three to five days. Photograph consistently; keep caps and conditions unchanged.

6. Compare the conditions and observations. If using the teacher’s earlier set, record its actual start date and label those observations separately.

7. Use the protection case cards to explain paint and sacrificial zinc. Predict what happens when each coating is scratched; this explanation is not a measurement from A–C.

Cleanup

• Leave labelled tubes in the assigned rack for observations. Staff collect desiccant, oil and nails separately after the study; follow the local disposal plan. Wash hands.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Rusting needs water and oxygen. “No air” is an experimental approximation: boiling and an oil layer reduce dissolved oxygen and re-entry. Rust is hydrated iron(III) oxide of variable composition. Sacrificial protection uses a more reactive metal in electrical contact with the iron; the metal corrodes preferentially.

Case / condition	Evidence or prediction	Explanation / limitation
A: air + water; dates		
B: oxygen access restricted; dates		
C: dry air; dates		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Record dated observations for A–C, or explain why observations are not yet available.

2. Use the comparisons to explain why water and oxygen are both needed.

3. Why must B use boiled water and an oil layer rather than ordinary water alone?

4. Explain paint protection and predict the consequence of a scratch.

5. Explain why zinc can protect scratched iron, but a copper contact is unsuitable.

6. Identify a control variable and one limitation of the three-tube design.