Corrosion and its prevention

4.10.3.1 · Using resources · revision notes

What corrosion is, the experiment that shows iron needs both air and water to rust, and how barrier methods and sacrificial protection prevent corrosion. This is in GCSE Chemistry only, not in Combined Science. Expect practical-based questions and 'explain' questions using the reactivity series on Paper 2.

Key facts

- Corrosion = destruction of materials by chemical reactions with substances in the environment
- iron + oxygen + water → hydrated iron(III) oxide (rust)
- Barrier methods: grease, paint, electroplating (and plastic coating)
- Galvanising = coating iron with zinc (sacrificial protection)
- Rusting needs air (oxygen) AND water
- Boiling removes dissolved air; an oil layer stops air re-dissolving; anhydrous calcium chloride dries the air
- Aluminium is protected by a layer of aluminium oxide
- Grade 7+ only Sacrificial metal is more reactive than iron, so it loses electrons instead of iron

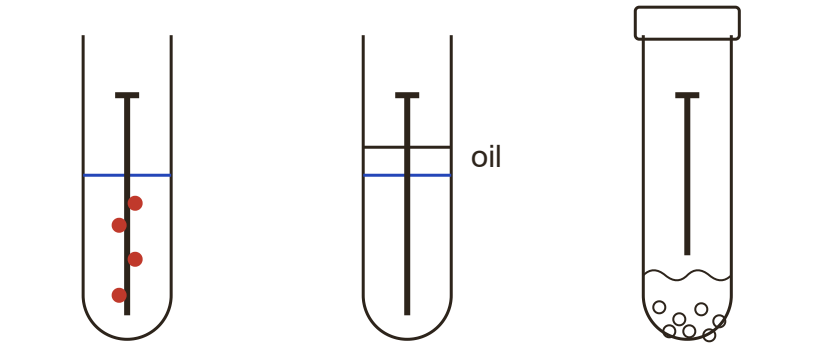
Notes

Corrosion and rusting

- **Corrosion** is the destruction of materials by chemical reactions with substances in the environment.
- **Rusting** is the corrosion of iron and steel. Iron needs **both air (oxygen) and water** to rust.
- iron + oxygen + water → hydrated iron(III) oxide (rust)

Experiment: what does iron need to rust?

- Tube 1: iron nail in tap water, open to the air. Result: rusts.
- Tube 2: nail in water that has been **boiled** (to remove dissolved air), with a layer of **oil** on top (to stop air dissolving back in). Result: no rust.
- Tube 3: nail in air dried by **anhydrous calcium chloride** (a drying agent that absorbs water), sealed with a bung. Result: no rust.



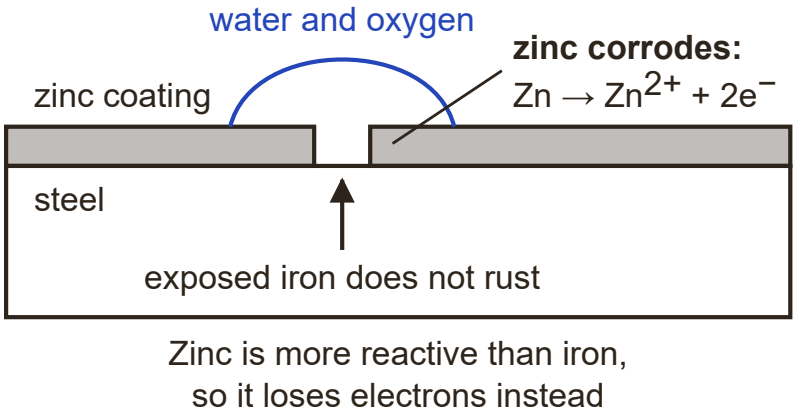
Iron rusts only when both air (oxygen) and water are present.

- Leave the tubes for about a week, then look for rust. Conclusion: iron rusts only when both air and water are present.

Preventing corrosion

- **Barrier methods** stop air and water reaching the metal: **greasing** or oiling, **painting**, coating with plastic, and **electroplating** (using electrolysis to coat the object with a thin layer of another metal).
- **Aluminium** is more reactive than iron but does not corrode away: a layer of **aluminium oxide** forms on its surface and protects the metal from further corrosion. It is a barrier that stops air and water reaching the aluminium.
- **Sacrificial protection**: iron is coated with, or connected to, a **more reactive metal**. **Galvanising** coats iron with **zinc**; blocks of zinc or magnesium are attached to ships' hulls and underground pipes. The more reactive metal corrodes instead of the iron.
- The more reactive metal loses electrons (is oxidised) more easily than iron, so it reacts instead of the iron. Even if a galvanised coating is scratched, the zinc still corrodes in preference to the exposed iron.

Grade 7+ only



Sacrificial protection still works when the zinc coating is scratched.

Grade 7+ only

- A coating of a less reactive metal, such as tin on steel food cans, is only a barrier. Once it is scratched, air and water reach the iron and it rusts. Grade 8+ only

How to answer each type of question

Interpret the rusting experiment

3 to 4 marks | Grade 5

1. Say which tube rusted and what each of the other tubes lacked.
2. Give the purpose of each part: boiling removes air, oil stops air dissolving, calcium chloride removes water vapour.
3. Conclude that both air and water are needed.

Example. A student set up three test tubes, each containing an iron nail.
Tube A: nail in tap water, no bung.
Tube B: nail in boiled water with a layer of oil on top.
Tube C: nail with anhydrous calcium chloride, sealed with a bung.
After one week only the nail in tube A had rusted.
(a) Why was the water in tube B boiled? (1 mark)
(b) What is the purpose of the anhydrous calcium chloride in tube C? (1 mark)
(c) What do the results show? (2 marks)

Model answer.

(a) To remove dissolved air (oxygen) from the water (1)

(b) To absorb water / to dry the air in the tube (1)

(c) Iron needs air (oxygen) to rust, shown by tube B, and water to rust, shown by tube C (1); both must be present for rusting (1).

Choose and justify a method of preventing rusting

2 to 4 marks | Grade 6

1. Match the method to the object: moving parts need oil or grease; large structures are painted; objects that must be shiny are electroplated; buried or underwater structures use sacrificial metals.
2. Explain how the method works: a barrier keeps out air and water, or a more reactive metal corrodes instead.
3. Say why other methods would not work as well.

Example. Suggest the best way to prevent rusting for each object. Give a reason each time.
(a) The chain of a bicycle (2 marks)
(b) A steel pipeline buried underground (2 marks)

Model answer.

(a) Oil or grease (1); it keeps air and water out while still letting the parts move, whereas paint would crack or rub off (1).

(b) Attach blocks of a more reactive metal such as magnesium (sacrificial protection) (1); a buried pipe cannot easily be repainted, and the magnesium corrodes instead of the iron (1).

Explain sacrificial protection

2 to 3 marks | Grade 7

1. Say that the protecting metal (e.g. zinc or magnesium) is more reactive than iron.
2. Say that it loses electrons (is oxidised) in preference to iron, so it corrodes instead.
3. If the coating is scratched, the iron is still protected because the zinc still reacts first.

Example. Steel buckets are galvanised with a coating of zinc.
Explain why the steel does not rust even when the zinc coating is scratched. (3 marks)

Model answer. Zinc is more reactive than iron (1). So zinc loses electrons / is oxidised in preference to iron (1). The zinc corrodes instead of the iron (sacrificial protection), so the exposed iron does not rust (1).

Compare coatings of more and less reactive metals

3 marks | Grade 8

1. Place each coating metal relative to iron in the reactivity series.
2. A less reactive coating is only a barrier: once scratched, the iron rusts.
3. A more reactive coating gives sacrificial protection even when scratched.

Example. Steel food cans are coated with tin. Tin is less reactive than iron.
Explain why the steel in a scratched tin-coated can rusts, but the steel in a scratched galvanised bucket does not. (3 marks)

Model answer. Tin is less reactive than iron, so it only acts as a barrier (1). When the tin is scratched, air and water reach the iron, which rusts (1). Zinc is more reactive than iron, so when a galvanised coating is scratched the zinc corrodes instead of the iron (sacrificial protection) (1).

Don’t lose marks

- Writing that iron rusts with air or water. It needs both.
- Saying the water is boiled to kill bacteria. It is boiled to remove dissolved air.
- Saying zinc protects iron because it is 'stronger' or 'less reactive'. The reason is that zinc is MORE reactive.
- Using 'rust' for other metals. Only iron and steel rust; other metals corrode.
- Saying aluminium does not corrode because it is unreactive. It is fairly reactive, but its oxide layer protects it.
- Calling aluminium's oxide layer sacrificial protection. It is a barrier that keeps air and water away from the metal.

More tips

Memory tricks

- Rust recipe: iron + air + water. Take away either air or water and there is no rust.
- Sacrificial = the more reactive metal 'sacrifices' itself to save the iron.
- Zinc and magnesium are above iron in the reactivity series (sacrificial); tin is below it (barrier only).
- The oil layer in tube 2 works like a lid that keeps air out of the water.

Exam technique

- In sacrificial protection answers, use the words 'more reactive' and 'loses electrons' or 'is oxidised instead of iron'.
- For the three-tube experiment, give the purpose of each condition, not just the result.
- For 'suggest a method' questions, match the method to how the object is used, e.g. moving parts, underground, needs to look shiny.

What each grade needs

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

Grade 3

Define corrosion and give an example

Corrosion is the destruction of materials by chemical reactions with substances in the environment; rusting is an example.

Grade 4

State the conditions needed for rusting

Iron needs both air (oxygen) and water to rust.

Grade 4

Name barrier methods of preventing corrosion

Greasing, painting and electroplating keep air and water away from the metal.

Grade 5

Describe the rusting experiment with three tubes

Nails in water open to air, in boiled water under oil, and in dry air; only the first rusts.

Grade 5

Explain why aluminium does not corrode away

A layer of aluminium oxide on its surface protects the metal from further corrosion.

Grade 6

Explain how galvanising protects iron

The zinc coating is a barrier and, if scratched, the more reactive zinc corrodes instead of the iron.

Grade 7

Explain sacrificial protection using relative reactivity

A more reactive metal loses electrons (is oxidised) in preference to iron, so the iron does not rust.

Grade 8

Compare sacrificial and barrier protection when scratched

A scratched paint or tin coating exposes iron, which then rusts; a scratched zinc coating still protects it.

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