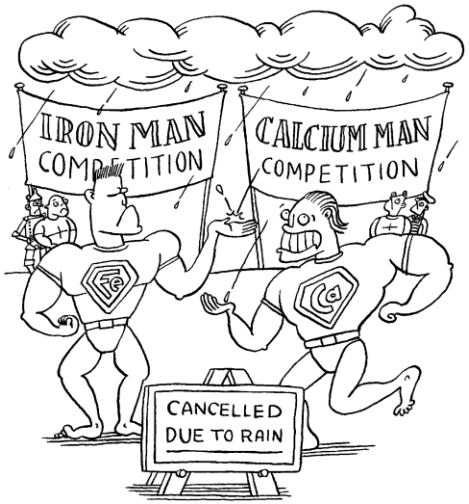
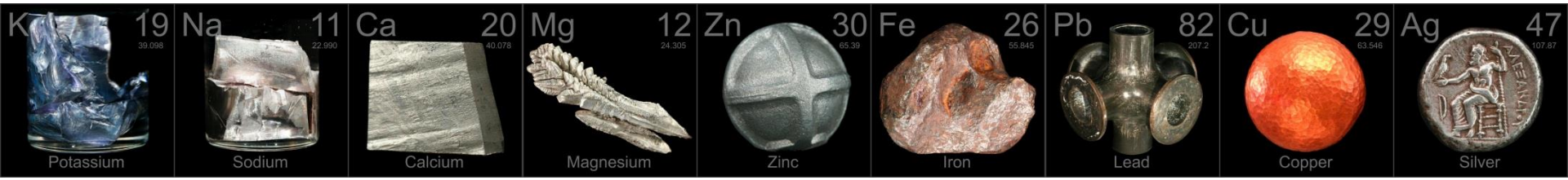


Reactivity Series of Metals



K **Na** **Ca** **Mg** **Zn** **Fe** **Pb** **Cu** **Ag**

More Reactive **Less Reactive**

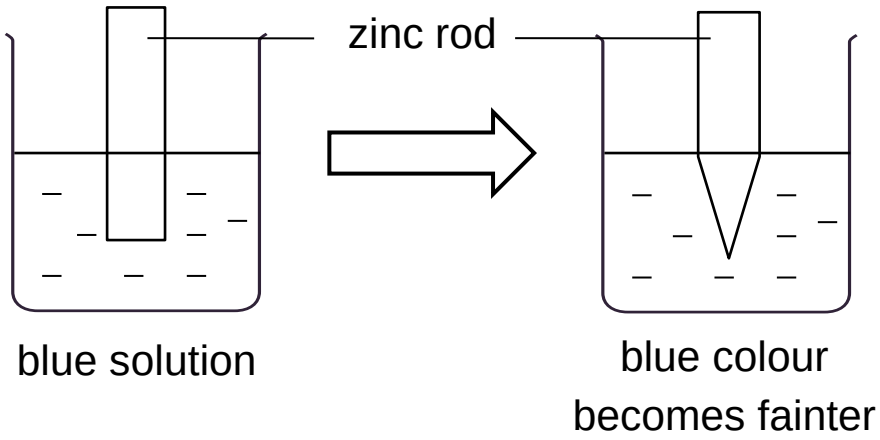
Displacement of Metals from Aqueous Solutions

$$Zn\,(s) + CuSO_4\,(aq) \rightarrow ZnSO_4\,(aq) + Cu\,(s)$$

reduced to

$$Zn\,(s) + Cu^{2+}\,(aq) \rightarrow Zn^{2+}\,(aq) + Cu\,(s)$$

oxidised to

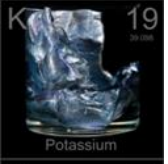


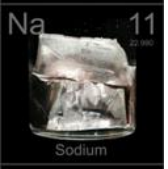
Displacement of Metals from Aqueous Solutions

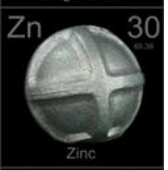
Observation & Explanation

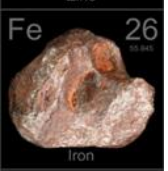
Zinc is **more reactive** than copper. As such, zinc will **dissolve** and **displace** copper from its solution. The **blue** copper(II) sulfate solution **turns** to form a **colourless** solution. **Reddish-brown/pink** deposit of copper metal is also formed at the bottom of the solution.

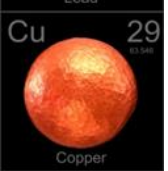
Displacement of Metals from Aqueous Solutions







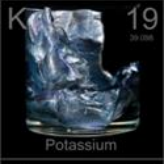


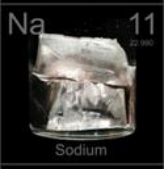


- Copper metal with magnesium nitrate solution

Observation & Explanation

Solution remains colourless. Magnesium is **more reactive** than copper. Hence, **no displacement occurs**.





Displacement of Metals from Metal Oxides

- A metal higher in the reactivity series can **reduce** the oxide of a metal lower in the series.

Aluminium powder is mixed thoroughly with iron(III) oxide and heated strongly.

$$2Al\ (s) + Fe_2O_3\ (s) \rightarrow 2Fe\ (l) + Al_2O_3\ (s)$$

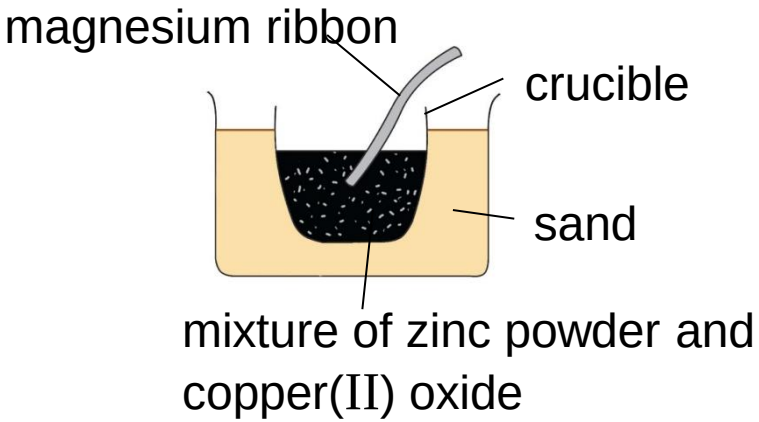
This reaction is known as the **thermit** reaction, which releases a large amount of heat energy. This process is used to weld railway lines together, where the molten iron formed flows into the gaps between rails, joining them tightly together.

Displacement of Metals from Metal Oxides

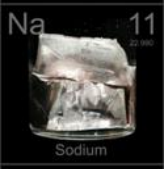
- A metal higher in the reactivity series can **reduce** the oxide of a metal lower in the series.

Zinc reacts with copper(II) oxide (with magnesium ribbon **acting as a fuse**)

$$Zn\ (s) + CuO\ (s) \rightarrow ZnO\ (s) + Cu\ (s)$$



Quick Check!



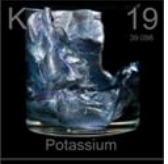
A large volume of copper(II) sulfate solution is left in an iron container overnight. Which statement describes what happens?

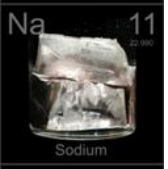
A The solution evaporates completely and some copper(II) sulfate crystals are left behind.

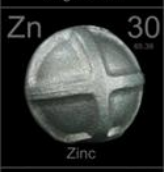
B The part of the container in contact with the solution is coated with copper.

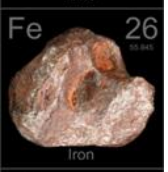
C Some fine iron particles are formed in the solution.

D Atmospheric oxygen reacts with the copper(II) sulfate to give black copper(II) oxide.









Concept Map

Metals

have

Physical Properties

Chemical Properties

include

Reactivity Series of Metals

More Reactive

K

Na

Ca

Mg

C

Zn

Fe

Pb

H

Cu

Ag

Less Reactive

as deduced from

Reactions of Metals

with

Water $H_2O(l)$

Steam $H_2O(g)$

Acid HCl(aq)

Reduction of Metal Oxides

by

Carbon C(s)

Hydrogen $H_2(g)$

Decomposition of Metal Carbonates

by

Heat

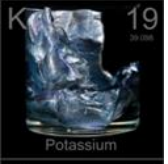
Metal Displacement Reactions

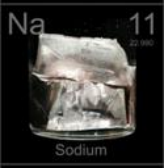
Learning Objectives

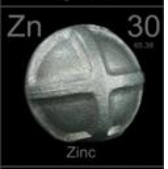
- Describe the essential conditions for the corrosion (rusting) of iron as the presence of oxygen and water; prevention of rusting can be achieved by placing a barrier around the metal, e.g. painting; greasing; plastic coating; galvanising

- Describe the sacrificial protection of iron by a more reactive metal in terms of the reactivity series where the more reactive metal corrodes preferentially, e.g. underwater pipes have a piece of magnesium attached to them

Corrosion in Everyday Life







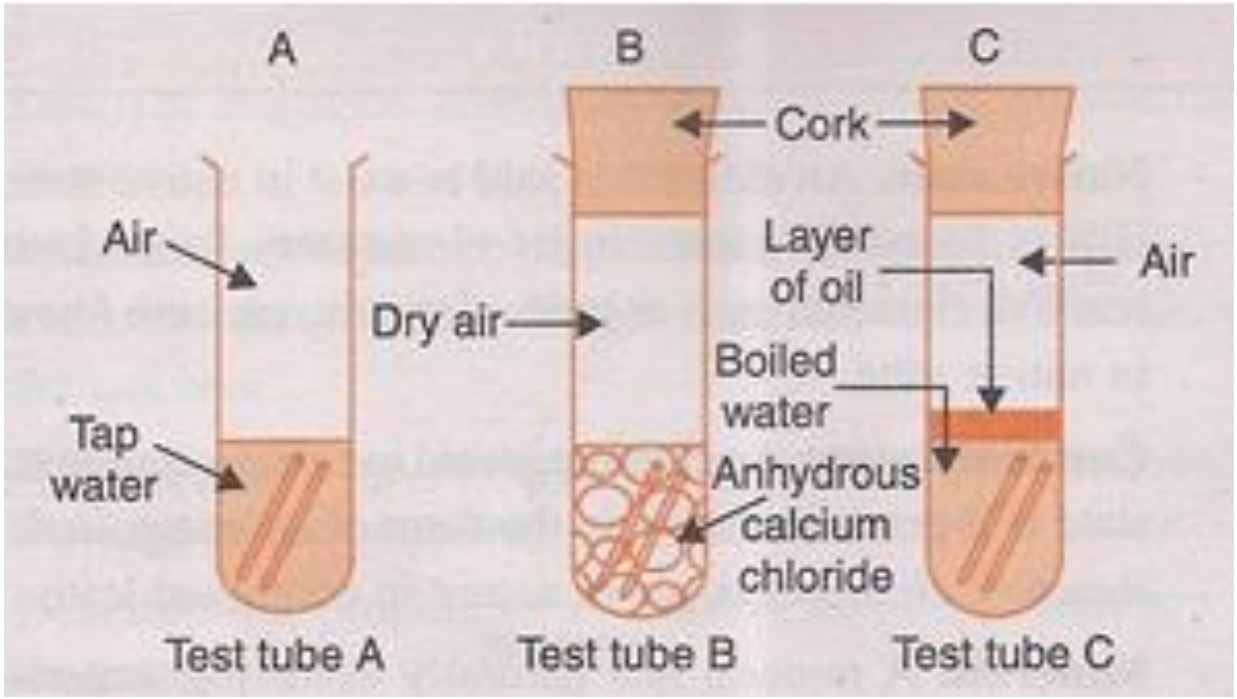
Rusting of Iron

- **Corrosion** involves the **oxidation** of a metal. Most metals form a microscopic surface film of oxide by reaction with oxygen.

- **Rusting** is a form of corrosion of **iron and its alloy** components, e.g. steel.

- Reddish-brown layer of rust is **hydrated iron(III) oxide, $Fe_2O_3.H_2O$**.

Rusting of Iron

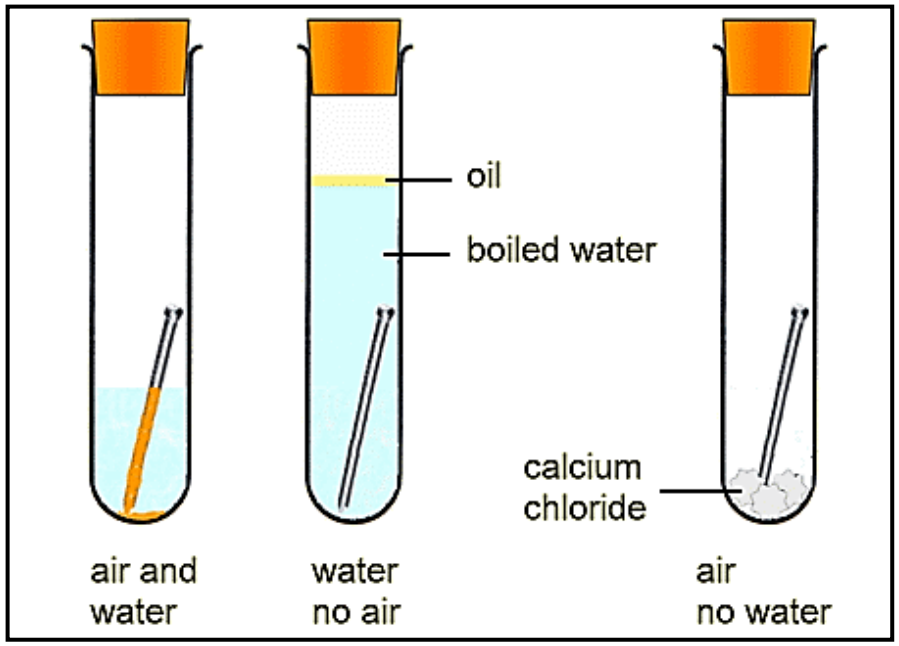


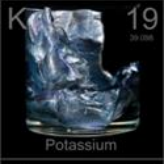
http://www.youtube.com/watch?v=-oAdk038mIQ

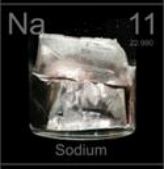
Rusting of Iron

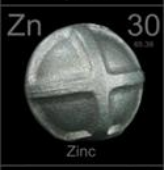
- During rusting, oxygen oxidises iron (in the presence of moisture) to form rust which is hydrated iron (III) oxide.

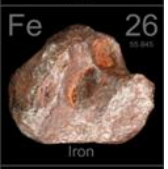
- Rusting requires **both** conditions:
  - **oxygen and**
  - **water**











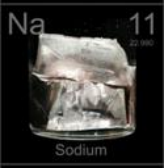
Quick Check!

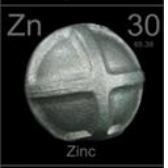
Explain the following:

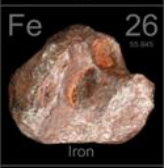
1. Little rusting occurs in Sahara desert.

2. Iron will not rust on the moon.

3. Iron objects rust easily in Singapore.



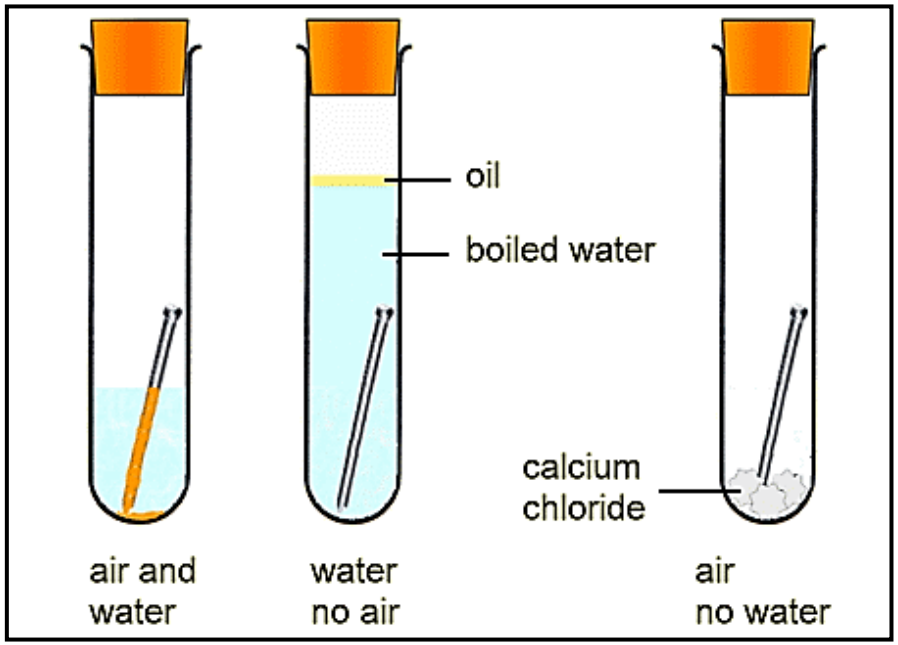


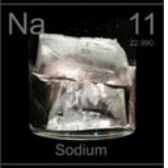


Quick Check!

Chemical Equation for rusting:

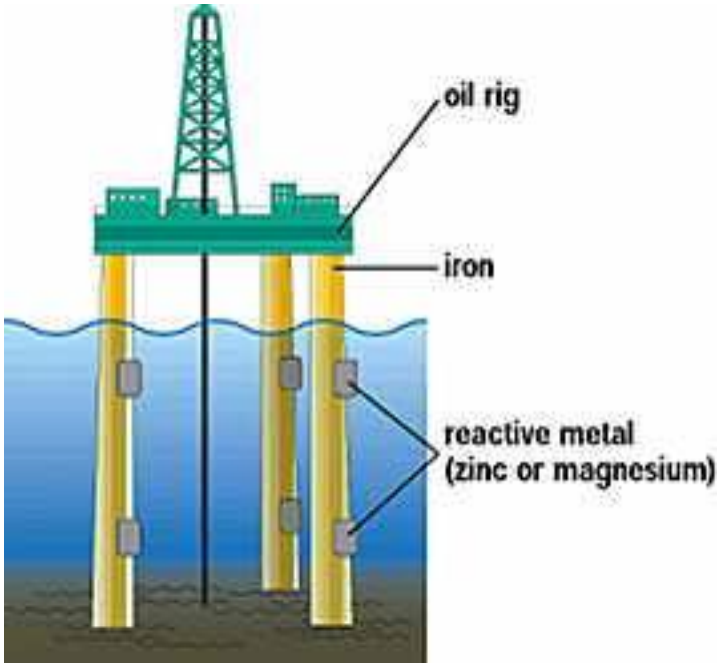
$$4Fe\,(s) + 3O_2\,(g) + 2H_2O\,(l) \rightarrow 2Fe_2O_3.H_2O\,(s)$$





Prevention of Rusting

- Methods of rust prevention typically work by preventing **oxygen** and **water** from reaching the iron.



Prevention of Rusting

1. **<u>Surface Protection</u>**

A surface protective layer of coat applied over iron/steel.

(a) **<u>Painting:</u>**

Used to protect large iron or steel structures such as ships or bridges

(b) **<u>Oiling / Greasing:</u>**

Used to protect moving parts such as machinery or bicycles (acts as lubricants as well)

(c) **<u>Plastic Coating:</u>**

Used to protect wires or paper clips

Prevention of Rusting

2. **<u>Sacrificial Protection</u>**

A **<u>more reactive</u>** metal is coated over iron/steel.

Being more reactive (than iron/steel), the metal will **<u>oxidise</u>** in preference to **<u>iron / steel</u>**.

(a) **<u>Galvanised iron with zinc / zinc plating:</u>**

Iron is coated with a layer of **<u>zinc</u>** by dipping the iron in hot molten zinc or by electroplating.

Prevention of Rusting

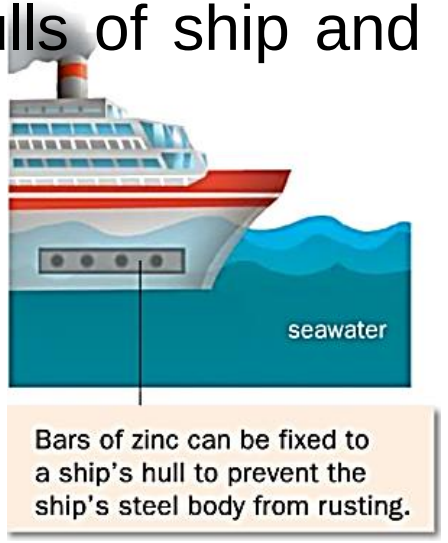
2. **<u>Sacrificial Protection</u>**

A **<u>more reactive</u>** metal is coated over iron/steel.

Being more reactive (than iron/steel), the metal will **<u>oxidise</u>** in preference to **<u>iron / steel</u>**.

(b) **<u>Protecting ships and oil rigs:</u>**

Blocks of zinc are attached to the hulls of ship and oil rigs.



Prevention of Rusting

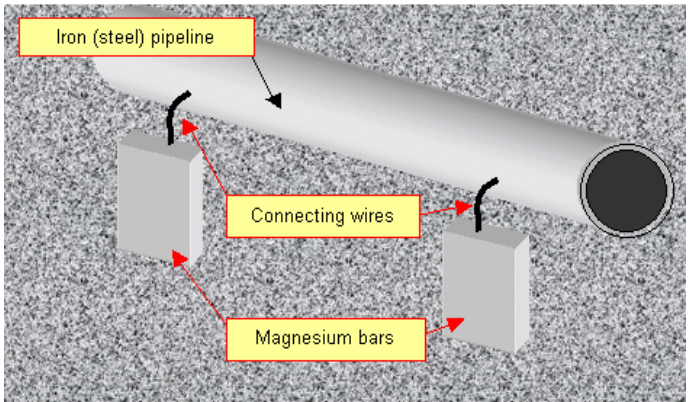
2. **<u>Sacrificial Protection</u>**

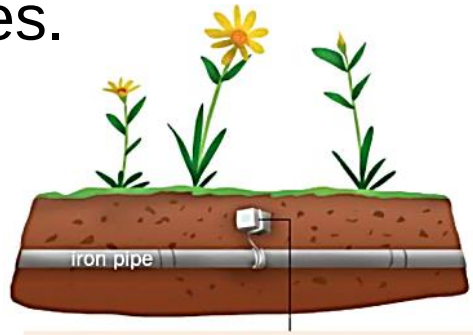
A **<u>more reactive</u>** metal is coated over iron/steel.

Being more reactive (than iron/steel), the metal will **<u>oxidise</u>** in preference to **<u>iron / steel</u>**.

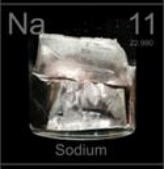
(c) **<u>Protecting underground pipes:</u>**

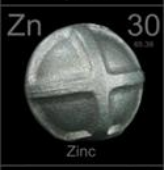
Pipes are attached to blocks of **<u>magnesium</u>** scrap metal, using insulated copper cables.

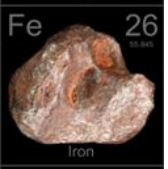




Heavy blocks of magnesium attached to underground pipes made of iron protect the pipes from rusting.







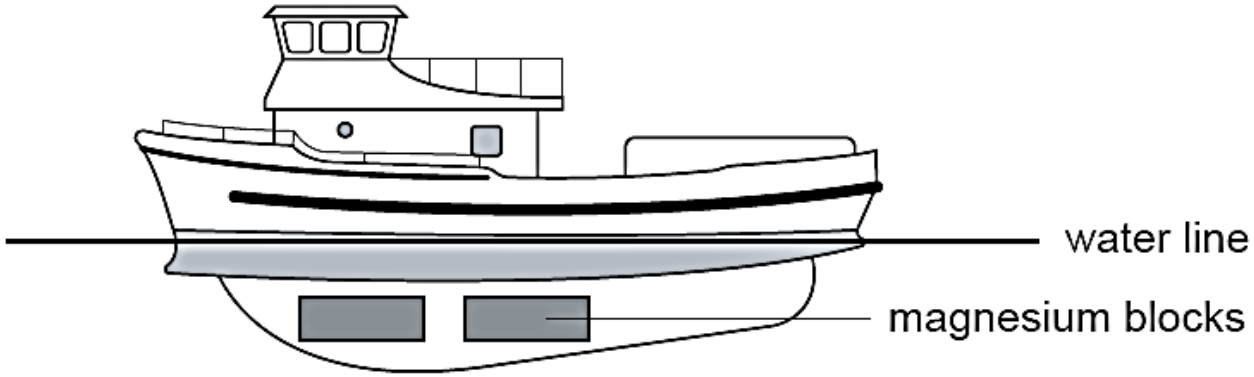
Prevention of Rusting

3. **<u>Alloying</u>**

Iron is alloyed with carbon, nickel and chromium to form **<u>stainless steel</u>**. Chromium gets **<u>oxidised</u>** to form chromium(III) oxide and **coats** over stainless steel to prevent rusting.

Quick Check!

The diagram shows a boat made from iron. Some magnesium blocks are attached to the iron below the water line.



Why does the magnesium stop the iron from rusting?

Quick Check!

Why does the magnesium stop the iron from rusting?

A Magnesium reacts in preference to the iron.

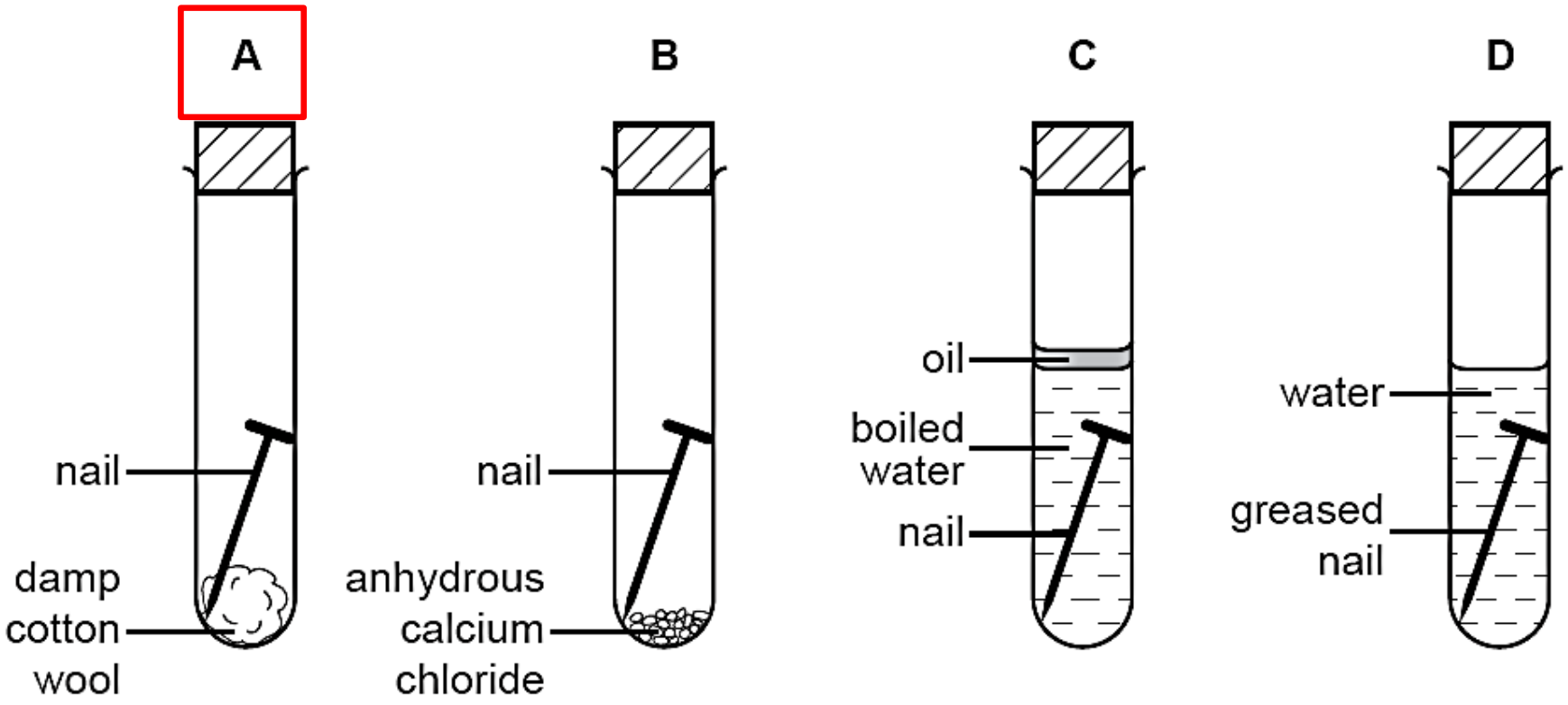
B Magnesium reacts to form a protective coating of magnesium oxide on iron.

C The magnesium forms an alloy with the iron.

D The magnesium stops oxygen in the water from getting to the iron.

Quick Check!

In which test-tube is the iron nail **most** likely to rust?



Quick Check!

Which metal should be used in the sacrificial protection of the hull of a boat made of iron?

A calcium

B copper

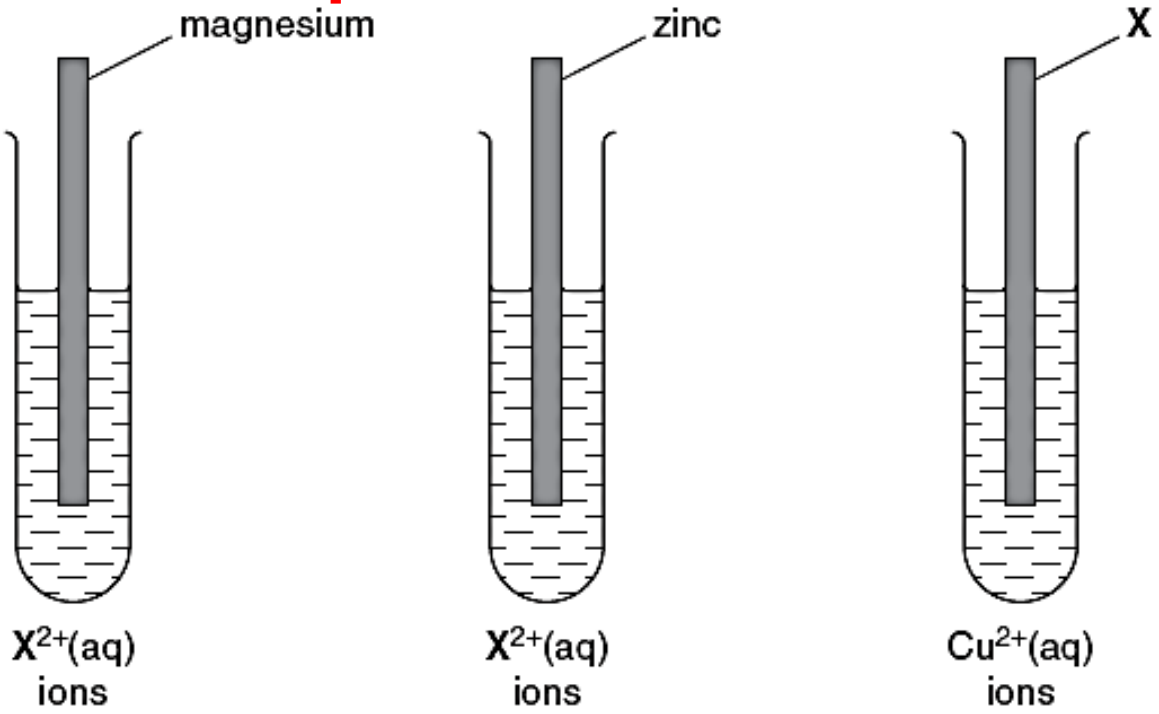
C lead

D zinc

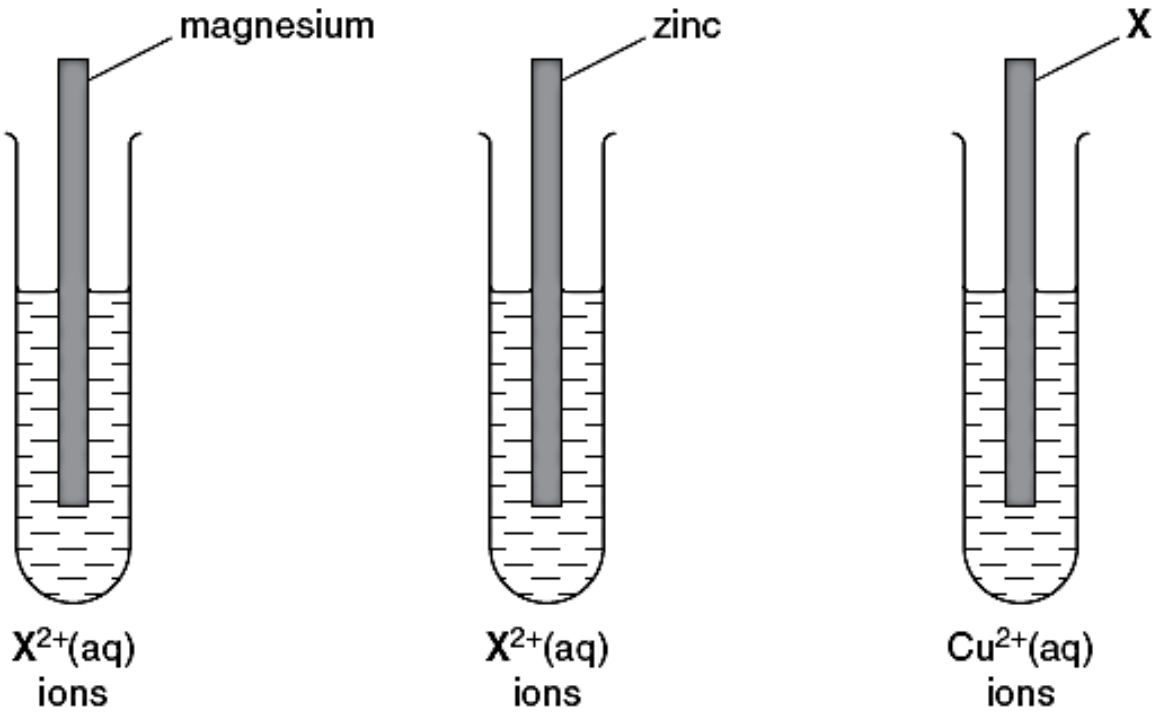
Quick Check!

A student conducted an experiment to conduct the reactivities of three different metals. Three test-tubes were arranged as in the diagrams below.

There was a **deposit** formed in all three tubes.



Quick Check!



What could **X** be?

A calcium

B iron

C silver

D sodium

Quick Check!

Iron will rust most rapidly in

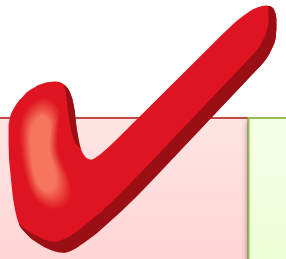
A sea water.

B tap water.

C air-free water.

D distilled water.

Up next…



Properties of Metals

Extraction of Metals

Recycling of Metals

Reactivity Series

Iron