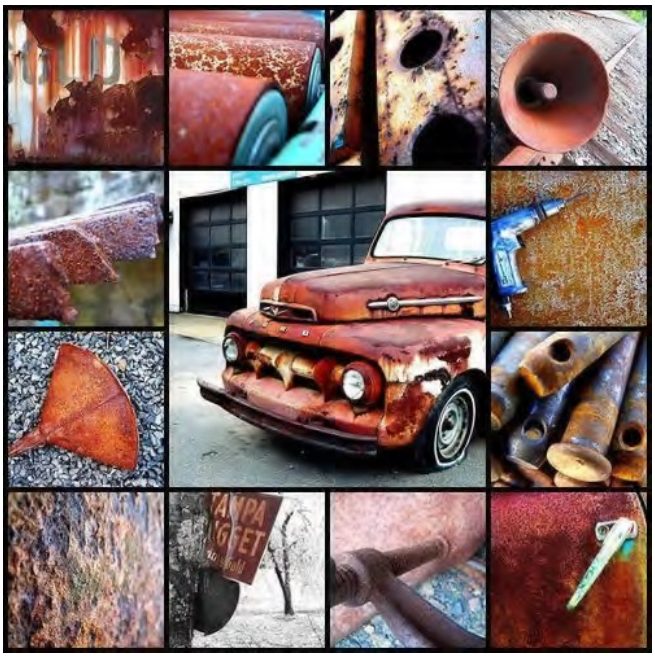
NEW WORDS

- rust
- corrosion
- corrosive
- rust-resistant
- steel

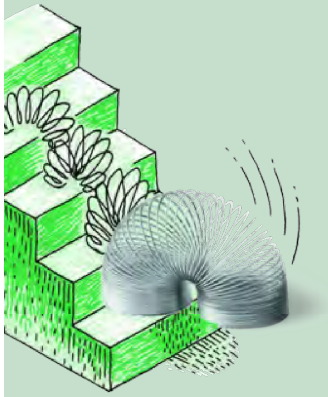
In the next section, we are going to return to the macroscopic world to see another example of the reaction between iron and oxygen that you should be very familiar with - the formation of rust.

3.4 The formation of rust

Do you know what rust is? The pictures below will provide some clues.



Different objects which rust.



ACTIVITY: The reaction between iron and oxygen in air

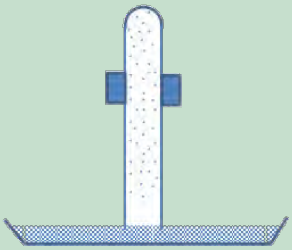
MATERIALS:

- test tube
- clamp
- retort stand
- dish
- iron filings
- water

INSTRUCTIONS:

1. Rinse a test tube with water to wet the inside.
2. Carefully sprinkle a spatula of iron filings around the sides of the test tube.
3. Invert the test tube in a dish of water. Use a clamp attached to a retort stand to hold the test tube in place.
4. Over the three days the water must remain above the lip of the test tube.

Here is a simple diagram showing the experimental setup with the clamp holding the test tube upright.



QUESTIONS:

1. What do the iron filings look like at the start of the experiment?

2. What are the reactants in this experiment?

3. Is there something present that is aiding or speeding up the reaction?

4. What does the product look like at the end of the reaction?

Rust is a word to describe the flaky, crusty, reddish-brown product that forms on iron when it reacts with oxygen in the air.

When your teacher burned the iron earlier, it reacted quickly with oxygen to form iron oxide. Here is a picture of iron oxide to remind you what it looked like.

A sample of iron oxide.

Rust is a form of iron oxide

When iron is exposed to oxygen in the air, a similar reaction occurs, but much more slowly. The iron is gradually 'eaten away' as it reacts slowly with the oxygen. Under wet conditions iron will rust more quickly.

Rust is actually a mixture of different oxides of iron, but the Fe_2O_3 of our earlier example is an important part of that. The rusting of iron is actually a good example of the process of corrosion.

Rusting tends to happen much faster near the ocean. Not only are there water droplets, but these droplets have salt in them and this makes them even more corrosive. Rusting also happens more quickly in the presence of acids. Inside laboratories, or factories where acids are used or stored, the air is also very corrosive. When the air in a specific area contains moisture mixed with acid or salt, we refer to the area as having a **corrosive climate.**

If you live in a corrosive climate, for example near the ocean, it is often better to make the window frames and doors of your house from wood instead of iron and steel, because wood does not rust. Many people also use aluminium as this metal does not rust.

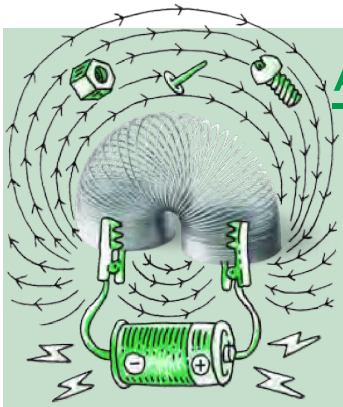
An abandoned car quickly rusts and corrodes near the sea.

The problem with rust

A garden sculpture that was intended to rust to give it more texture.

Rust is a natural process and its effects can be quite beautiful.

However, iron and rust (iron oxide) are completely different materials and therefore have different properties.



ACTIVITY: Why is rust a problem?

1. Let's imagine we have manufactured something out of iron. What properties of iron do we want to take advantage of?

2. What objects do you think we make out of iron where these properties are desirable?

A rusted chain.

A rusted door hinge.

3. When an item is made of iron, we might want to protect it from rust, to prevent it from losing those desired properties. Do you think the rusty chain and door handle in the following photos will be as strong and flexible as when they were new? Why not?

You might have learnt in previous grades that iron can be strengthened, and made more resistant to rust, by mixing it with other elements to turn it into **steel**.

Steel is used in the construction of buildings, because it is very strong. Steel is not completely rust-resistant, however, and needs to be protected against rust, especially in moist and corrosive climates.

A building under construction. You can see the framework made of steel.

Steel reinforcement to support a building. As you can see, steel can also rust.

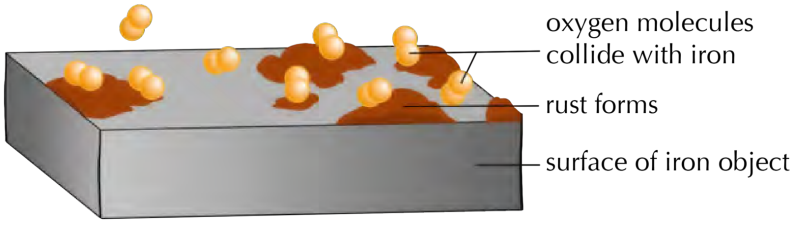
NEW WORDS

- collide
- barrier
- exposed
- porous
- penetrate
- chromed metal
- galvanised metal
- galvanise
- oxidise

In the next section, we will learn about the different ways in which iron and steel can be protected against rust.

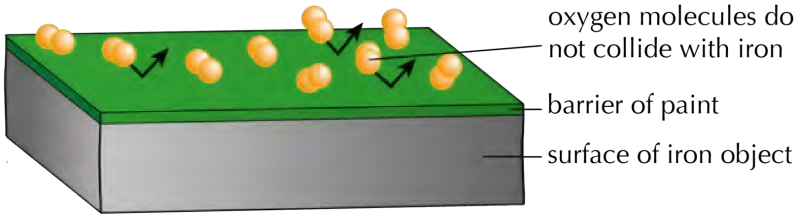
3.5 Ways to prevent rust

Rust forms on the surface of an iron or steel object, when that surface comes into contact with oxygen. The oxygen molecules collide with the iron atoms on the surface of the object, and they react to form iron oxide. If we wanted to prevent that from happening, what would we have to do?



Paint provides a barrier to rust

If we wanted to prevent the iron atoms and oxygen molecules from making contact, we would need to place a barrier between them. That is what we are doing when we paint an iron surface to protect it from rust.



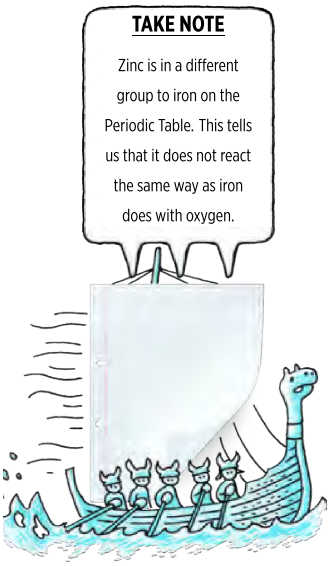
Paint is not the ultimate barrier, though. If the paint surface is scratched, or it starts to peel off, the metal will be exposed and rust can still form.

Other metals as barriers to rust

Rust is a porous material. This means that air and water can penetrate through the rust on the surface of the object to reach the iron underneath. The iron will continue to corrode even if it has a thick layer of rust covering it. So even though the iron surface is covered, it is not protected, because the oxygen molecules can still reach the iron to react with it.

There are a number of other ways to stop or slow down rust. One way to protect the iron surface is to cover it with a metal that does not corrode, like chromium, for instance. Taps and bathroom fittings are often made of iron that has been 'chromed'. They have been covered with a layer of chromium to protect the iron surface from contact with the air.

Chromed taps in a basin.



Zinc also reacts with oxygen to form zinc oxide:

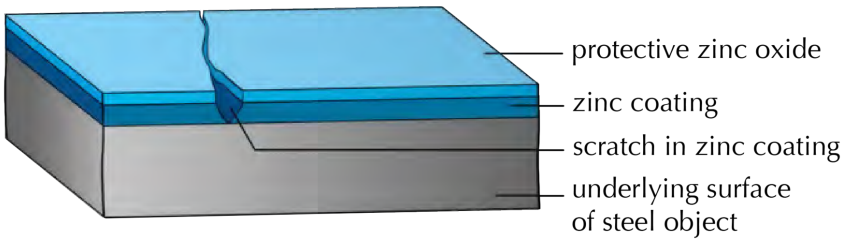
$2\ Zn + O_2 \rightarrow 2\ ZnO$

What group is zinc in?

_____

Zinc oxide (ZnO) is not a porous oxide, but forms a dense protective layer that cannot be penetrated by oxygen or water. Iron can be coated with a thin layer of zinc in a process called **galvanising**. The zinc layer quickly reacts with oxygen to become zinc oxide. This layer protects the zinc underneath it from being further oxidised. It also protects the iron underneath the zinc from contact with oxygen.

The following diagram shows a segment of galvanised steel, with a scratch in the protective coating. What do you think will happen to the steel that is exposed to the air by the scratch in the coating?



A segment of galvanised steel, showing damage to the zinc coating.

VISIT

Why do apples turn brown? (video)

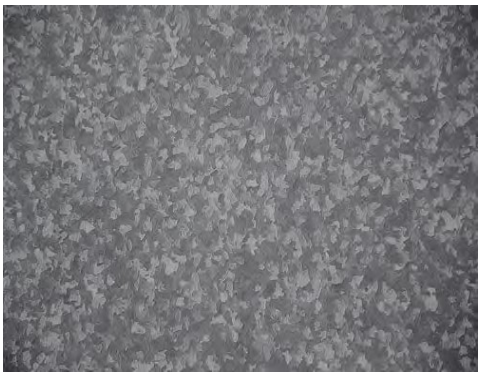
bit.ly/17iQvh2

Iron that is galvanised is used for many different purposes. You would most probably have seen it being used as galvanised roof panels or other galvanised building materials, such as screws, nails, pipes, or floors.

Galvanised panels used for walls or roofs.

A galvanised watering can.

Galvanised nuts and bolts.



Galvanised flooring.

DID YOU KNOW?

Cut apple slices turn brown as the iron compounds in the apple flesh are reacting with the oxygen in the air! The reaction is aided by an enzyme in the apple, so dripping lemon juice onto the slices will destroy the enzyme and prevent them from turning brown.

In this chapter we learnt how metal oxides form. We saw two demonstrations of reactions in which metals oxides formed as products. Finally, we learnt about a metal oxide (iron oxide or rust) from our everyday experience as well as ways to prevent objects from rusting, especially those used in buildings and industry.