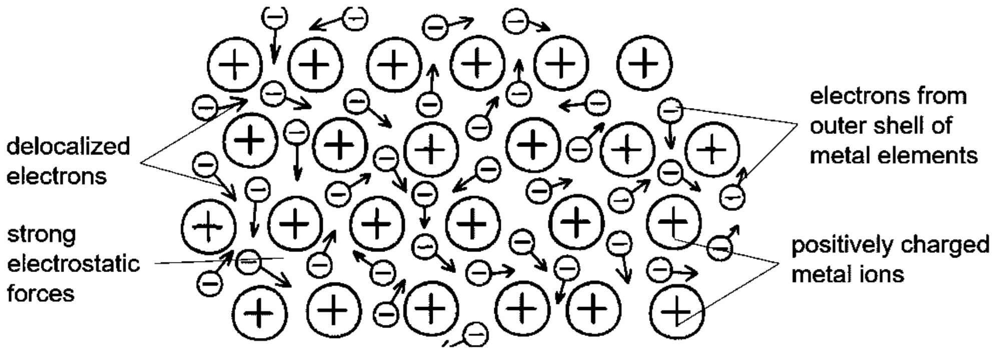
PERIODICITY

Metals

A metal is an element which can form positive ions by the loss of valence electrons (with the exception of hydrogen which is not a metal).

The atoms within metals are held together by a **delocalized electron cloud** which moves randomly over the metal structure. This free moving electron cloud is responsible for a strong **metallic bond** over the metal structure, which is responsible for the physical properties of the metal.



Delocalized electron cloud

Relating metallic bonds to metallic properties

- **Most metals are <u>solids at room temperature</u>**

The **electrostatic forces** between the metal atoms and the delocalized sea of electrons are **very strong**, so need lots of energy to be broken.

This means that most compounds with metallic bonds have very high melting and boiling points, so they're generally solid at room temperatures.

- **Metals are <u>good conductors of heat and electricity</u>**

The **delocalized electrons** carry **electrical current** and thermal (heat) energy through the whole structure, so metals are good conductors of electricity and heat.

When the metal is not connected to a power supply, the electrons of the delocalized electron cloud/sea of electrons move randomly. However, when the metal is connected to a power supply and electricity is made to flow through it, the electrons move towards the positive poles.

- **Most metals are <u>malleable</u>**

The layers of atoms in a metal can **slide over each other**, making metals malleable – this means that they can be bent or hammered or **rolled into flat sheets**.

Permanent hardness

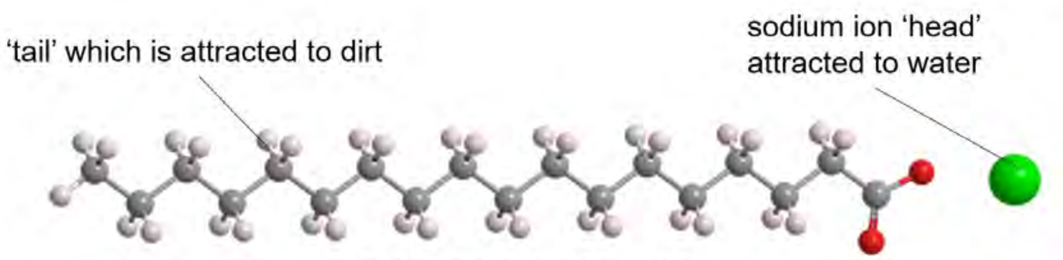
Permanent hardness is caused when water passes over rocks containing dissolved **calcium sulfate**, $CaSO_4$, which does not decompose when heated.

Therefore, unlike temporary hardness, permanent hardness is **not** removed by boiling the water.

Like temporary hardness, permanent hardness also forms scum and does not lather well.

Scum formation

Soap is made by boiling natural fats and oils with sodium hydroxide. The soap molecules, for example, sodium stearate, have a long 'tail' which is attracted to soil or dirt and the sodium ion end ('head') which is attracted to water. In this way, dirt is lifted off a substance and is carried away by the water.



Sodium stearate molecule (soap)

However, when added to hard water, **soap** first reacts with the compounds responsible for making water hard, that is, with **calcium** and **magnesium ions** (Ca^{2+} and Mg^{2+}).

- On doing so, **insoluble calcium and magnesium stearate compounds** are formed.
- Unlike other insoluble compounds, these **precipitates** remain on the surface of the water and are known as **scum**.

$$2NaSt_{(aq)} + Ca(HCO_3)_{2(aq)} \rightarrow CaSt_{2(s)} + 2NaHCO_{3(aq)}$$

sodium stearate (soap) hard water scum sodium hydrogen carbonate

$$2NaSt_{(aq)} + Mg(HCO_3)_{2(aq)} \rightarrow MgSt_{2(s)} + 2NaHCO_{3(aq)}$$

Since a lather with soap only forms when ALL the calcium and magnesium ions have been eliminated, i.e, precipitated as scum, it is best to use **soft water** for washing purposes as with hard water, the stearate group from soap is first used to precipitate the calcium and magnesium ions from the water, not to form a lather.

2. With water (steam)

Being above hydrogen in the electrochemical series, iron is expected to react with water. It does so with difficulty, so it is the **heated** metal which reacts with **steam** to form the black tri iron tetraoxide (**Fe_3O_4**) and hydrogen.

$$3Fe_{(s)} + 4H_2O_{(g)} \xrightarrow{\Delta H} Fe_3O_{4(s)} + 4H_{2(g)}$$

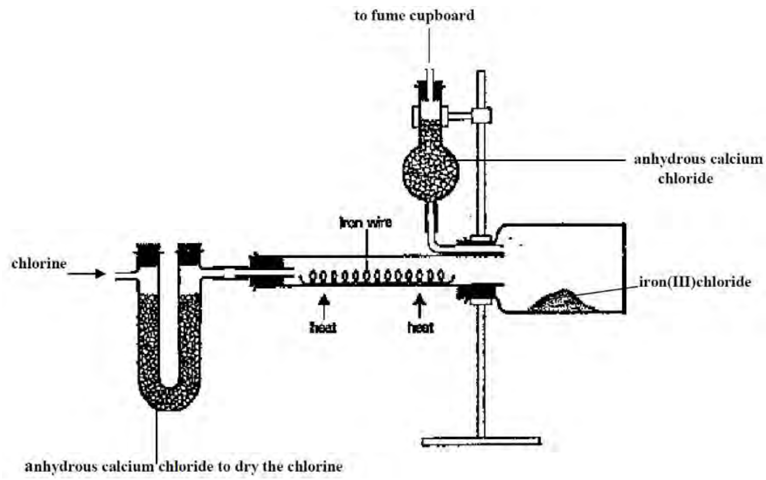
3. With dilute acids

As expected, iron reacts with dilute acids. However, the reaction is very **slow**. When iron reacts with dilute acids, the **iron (II) salt**, that is the salt containing the Fe^{2+} ion is **ALWAYS** liberated over the iron (II) salt. The reaction also produces hydrogen gas.

$$Fe_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2(aq)} + H_{2(g)}$$

4. With dry chlorine

Iron reacts with dry chlorine to form **iron (III) chloride**. This reaction can be used to **prepare** the salt. Iron (III) chloride is hygroscopic – when anhydrous it is **black**, but when hydrated, it forms a reddish-brown/**yellow** solid. It is also a sublimate.



$$2Fe_{(s)} + 3Cl_{2(g)} \xrightarrow{\Delta H} 2FeCl_3$$

The glass tube is continuously heated to **prevent the condensation** of the iron (III) chloride in this part of the apparatus.

Colour of iron compounds

- Iron compounds having an oxidation state of **+2** are usually **green** in colour.
- Iron compounds having an oxidation state of **+3** are usually **reddish-brown**/yellow in colour.
- If soluble, iron (II) and iron (III) compounds give green and reddish-brown/yellow solutions respectively.

Bleaching action of chlorine water

The bleaching process involves decolourization of coloured materials. Chlorine bleaches by the process of **oxidation**, in which it needs moisture to do so.

Chlorine reacts with water to form two acids: **hydrochloric** and **hypochlorous** acid:

$$Cl_{2(g)} + H_2O_{(l)} \rightarrow HCl_{(aq)} + HClO_{(aq)}$$

Here, we can see that one chlorine atom gets oxidized and the other gets reduced:

$$Cl^0 - e^- \rightarrow Cl \text{ (oxidation)}$$

$$Cl^0 + e^- \rightarrow Cl^- \text{ (reduction)}$$

The bleaching action is done by the **hypochlorous acid**. Hypochlorous acid has chlorine atom in the (+1) oxidation state, so it is **unstable** and it easily **dissociates** and forms nascent oxygen:

$$HClO \rightarrow HCl + [\ O\ ]$$

Nascent oxygen is a very powerful oxidising agent because it is very unstable, hence, it will react with coloured material effectively and oxidize it to a compound that is colourless (**bleaching** it). The same oxidation action is used to kill (oxidize) germs (sterilization).

Test for chlorine

Chlorine can be tested for by exposing it to **moist** blue litmus paper.

If chlorine gas is present, the moist blue litmus paper will be **bleached white**. It my turn red briefly before bleaching, as acids (hydrochloric acid) are produced when chlorine comes into contact with water.

Uses of chlorine

- Chlorine is used as a **disinfectant** – it kills bacteria. It is used to kill bacteria in drinking water and **swimming pool**s.
- Chlorine is used to make **bleach** – this is done by dissolving it in sodium hydroxide solution to form **sodium hypochlorite**. Domestic bleach contains about 5% NaOCl.
- Chlorine is used in the manufacture of many chemicals including **insecticides**, CFCs and the polymer PVC.