Metals and their Reactivity

Reactivity Series

- The **reactivity series** is a list of metals which are arranged in order of their reactivity. The most reactive metals are at the top, while the least reactive metals are at the bottom.

- Carbon and hydrogen are non-metals which are often included in the reactivity series for comparison.

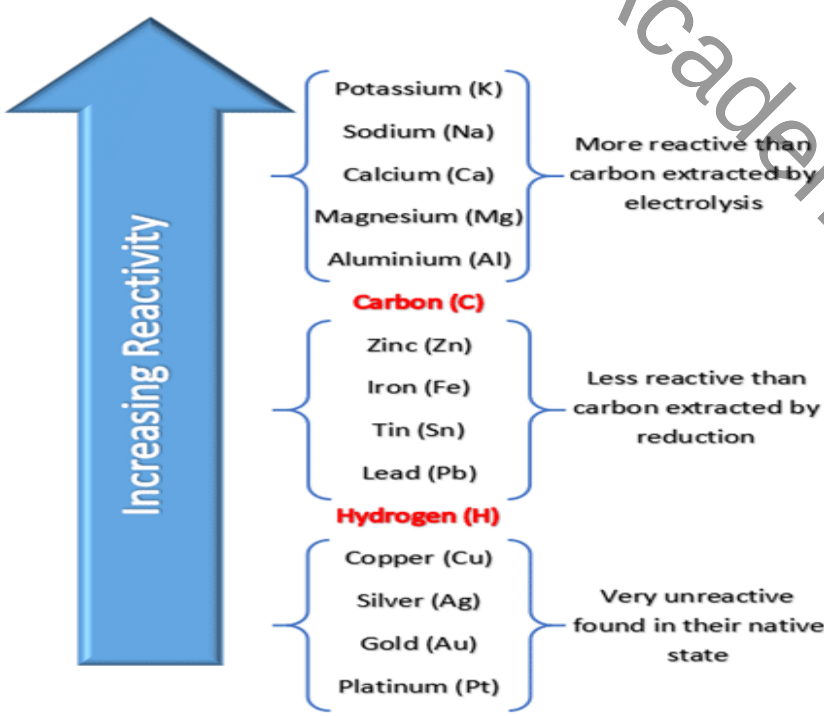
- When metals react, they lose electrons to form positive ions (cations).

$$M \rightarrow M^+ + e^-$$

- How easily a metal loses electrons is a measure of its reactivity. Therefore, the more easily a metal loses electrons, the higher it is placed in the reactivity series.

- Metals at the top of the series oxidise more easily, meaning they lose electrons more readily. In contrast, metals at the bottom of the series are less reactive and are more resistant to oxidation. This means they do not lose electrons easily.

- More reactive metals tend to have more vigorous reactions compared to less reactive metals.



Reactions of metals with acids

- We can use the reactions of metals with acids to tell us **how reactive** that metal is. The more vigorously it reacts, the more reactive the metal. The slower the reaction (sometimes there is no reaction at all), the less reactive the metal.

- Metals react with acids to form a **salt** and **hydrogen**, as described in the equation below:

METAL + ACID ⟶ SALT + HYDROGEN

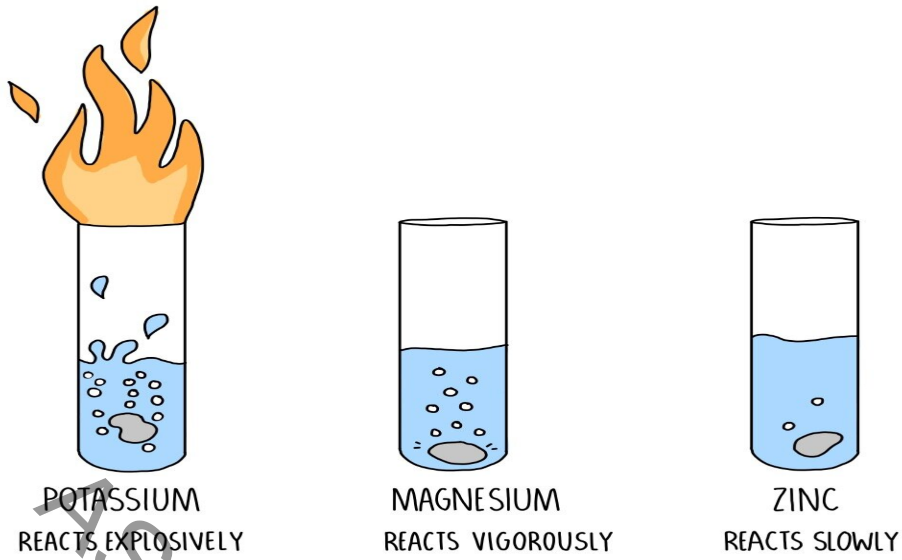
Procedure:

1. Add equal volumes of **dilute hydrochloric acid** or **dilute sulfuric acid** into a series of test tubes

2. Then add a **equal mass of metal** to each test tube. It is important that each metal has the **same surface area** because this will affect the rate of reaction.

3. Count the **number of bubbles** produced in a given time. The bubbles are **hydrogen gas** and can be confirmed using a lit splint, which will produce a **'squeaky pop'** when the hydrogen burns.

4. The faster the bubbles are given off, the **faster the rate of reaction** and the **more reactive** the metal.



Metals with Acids Observations

Metal	With dilute hydrochloric acid	With dilute sulfuric acid
Magnesium	Dissolves quickly, gets hot, gas given off which goes pop with a lighted splint, colourless solution left	Rapid bubbling, splint goes pop, metal dissolves
Iron	Very slow bubbling	Slow reaction, small bubbles seen
Zinc	Bubbles given off, metal slowly dissolves	Metal dissolves forming colourless solution, gas given off slowly

Reactions Table

Metal	Sulfuric acid	Hydrochloric acid
Magnesium	$Mg (s) + H_2SO_4 (aq) \rightarrow MgSO_4 (aq) + H_2 (g)$	$Mg (s) + 2HCl (aq) \rightarrow MgCl_2 (aq) + H_2 (g)$
Zinc	$Zn (s) + H_2SO_4 (aq) \rightarrow ZnSO_4 (aq) + H_2 (g)$	$Zn (s) + 2HCl (aq) \rightarrow ZnCl_2 (aq) + H_2 (g)$
Iron	$Fe (s) + H_2SO_4 (aq) \rightarrow FeSO_4 (aq) + H_2 (g)$	$Fe (s) + 2HCl (aq) \rightarrow FeCl_2 (aq) +$ H2 (

Conclusion

The metals can be ranked in reactivity order **Mg > Zn > Fe**

Reaction of metals with water

- We can also use the reaction of metals with **water** to determine **order of reactivity**. The equation for this reaction is:

METAL + WATER → METAL HYDROXIDE + HYDROGEN

- For example, lithium reacts with cold water to form lithium hydroxide and hydrogen gas.

Lithium + Water → Lithium hydroxide + Hydrogen

$$2Li (s) + 2H_2O (l) \rightarrow 2LiOH (aq) + H_2 (g)$$

- **Reactive metals** (such as potassium, sodium, lithium and calcium) will **react rapidly** in **cold water**
- **Less reactive metals** (such as magnesium, zinc and iron) won't react with cold water but will react with **water vapour** (steam)
- **Unreactive metals** (such as copper, silver and gold) **won't react** with either cold water or steam

Extractions of metals:

- Metals have to be separated out from their Oxides. Most metals are not found in pure form. They tend to be fairly reactive. They mostly found in compounds and have to be extracted before use.
- A reaction in which Common metals like iron and aluminium react with oxygen to form oxides this process is known as **oxidation**
- A reaction in which metals are separated out from their oxides to get pure Metal is called **reduction reaction**

Formation of metal Ore

- Reactive metals readily form compounds with other elements in the Earth's crust.
- An **ore** is a rock that contains enough metal to make it economically viable to extract the metal. Many ores contain metal oxides, while metal sulfides and metal carbonates are also common.
- For example, magnesium can be oxidise to make magnesium oxide

Magnesium + oxygen → **Magnesium oxide**

$$2Mg + O_2 \rightarrow 2MgO$$

- Two common examples of oxide ores are:

1. Haematite – Iron ore
2. Bauxite – Aluminium ore

Methods of Extracting Metals

- The extraction of metals depends on their reactivity. A metal that is less reactive than carbon can be extracted by heating it with carbon. As carbon is more reactive, it will displace the metal from the oxide. This process forms a pure metal.

- For example, heating copper(II) oxide with carbon will produce molten copper and carbon dioxide, as shown in the equation:

Copper oxide + Carbon → Copper + Carbon dioxide

$$2CuO\ (s) + C\ (s) \rightarrow 2Cu\ (l) + CO_2\ (g)$$

- Copper lost oxygen, so it was reduced
- Carbon gained oxygen, so it was oxidised

Extraction of metals by reduction with carbon

- Another key example is the extraction of pure iron from iron(III) oxide by heating it with carbon. The iron(III) oxide solids are reduced to molten iron, and the reaction also forms carbon monoxide, as shown in the equation:

Iron(III) oxide + Carbon → Iron + Carbon monoxide

$$Fe_2O_3\ (s) + 3C\ (s) \rightarrow 2Fe\ (l) + 3CO\ (g)$$

- The carbon monoxide (CO) can be oxidised further to produce carbon dioxide, which is less harmful when inhaled.
- Extracting metals by heating them with carbon is more cost-effective than using electrolysis. However, if a metal is more reactive than carbon, it cannot be reduced by carbon. In this case, the metal has to be extracted using electrolysis.
- Unreactive metals, such as gold and silver, are found in the Earth's crust as pure metals. This is because they do not easily react with other substances, so they can be mined directly from the Earth's crust.

Reactivity	Metal	Method of Extraction
Most reactive	Potassium	Extracted by electrolysis of molten compounds
	Sodium	
	Lithium	
	Calcium	
	Magnesium	
	Aluminium	
	Carbon	
	Zinc	Extracted by reduction, by heating with carbon
	Iron	
	Copper	
	Silver	Found as pure elements in nature
Least reactive	Gold	