$CuSO_4(aq)$

This means that copper can displace silver from its solution, but silver cannot displace copper from its solution. Thus, ***copper is more reactive than silver.***

REACTIVITY SERIES OF METALS

We have learnt that some metals are chemically very reactive while others are less reactive or do not react at all. We have also learnt that zinc metal can displace copper from its solution while copper cannot displace zinc from its solution. These observations raise some questions in our mind :

1. *Why are some metals chemically very reactive while others are less reactive ?*
2. *Which metal can displace another metal from its solution ?*

On the basis of reactivity of different metals with oxygen, water and acids as well as displacement reactions, the metals have been arranged in the decreasing order of their reactivities.

The arrangement of metals in order of decreasing reactivities **is** called **reactivity series** or **activity series of metals**.

The activity series of some common metals is given in Table 1. In this table, the **most reactive metal** is placed at the **top** whereas the **least reactive** metal is placed at the **bottom**. As we go down the series the chemical reactivity of metals decreases.

Reasons for Different Reactivities

In the activity series of metals, the basis of reactivity is the tendency of metals to lose electrons. If a metal can lose electrons easily to form positive ions, it will react readily with other substances. Therefore, it will be reactive metal. On the other hand, if a metal loses electrons less rapidly to form a positive ion, it will react slowly with the other substances. Therefore, such a metal will be less reactive. For example, alkali metals such as sodium and potassium lose electrons very readily to form alkali metal ions, therefore, they are very reactive.

It may be noted that hydrogen is not a metal but even then it has been placed in the reactivity series. This is due to the fact that

(*i*) Hydrogen can also lose electron and form positive ion, H^+.

(*ii*) Hydrogen has also been included in the series to compare the reactivities of metals with respect to it.

Table 1. Reactivity series of metals

REACTIVITY INCREASES ↑		Potassium	K
		Sodium	Na
		Calcium	Ca
		Magnesium	Mg
	Metals more reactive than hydrogen	Aluminium	Al
		Zinc	Zn
		Iron	Fe
		Nickel	Ni
		Tin	Sn
		Lead	Pb
		Hydrogen	**H**
		Copper	Cu
	Metals less reactive than hydrogen	Mercury	Hg
		Silver	Ag
		Gold	Au
		Platinum	Pt

(Most reactive metal)

REACTIVITY DECREASES ↓

(Least reactive metal)

Displacement of Hydrogen from Acids by Metals

Let us consider, displacement of hydrogen from acids by metals. All metals above hydrogen in the reactivity series (*i.e.*, more active than hydrogen) like zinc, magnesium, nickel can liberate hydrogen from acids like HCl and H_2SO_4. These metals have greater tendency to lose electrons than hydrogen. Therefore, the H^+ ions in the acids will accept electrons and give hydrogen gas as :

$$\underset{\text{Metal}}{M} \longrightarrow M^+(aq) + e^-$$

$$\underset{\text{(From acid)}}{H^+(aq)} + e^- \longrightarrow H$$

$$H + H \longrightarrow H_2\uparrow$$

The metals which are below hydrogen in the reactivity series (*i.e.*, less reactive than hydrogen) like copper, silver, gold cannot liberate hydrogen from acids like HCl, H_2SO_4, etc. These metals have lesser tendency to lose electrons than hydrogen. Therefore, they cannot lose electrons to H^+ ions.

Reactivity Series and Displacement Reactions

The reactivity series can also explain **displacement reactions**. In general, a more reactive metal (placed higher in the activity series) can displace the less reactive metal from its solution. For example, zinc displaces copper from its solution.

$$Zn(s) + CuSO_4(aq) \longrightarrow ZnSO_4(aq) + Cu(s)$$

This displacement reaction occurs because zinc is more reactive than copper and can readily lose electrons. These electrons are accepted by copper ions and form copper metal, which gets deposited on the zinc strip. Since the Cu^{2+} ions which give blue colour to the solution are gradually replaced by Zn^{2+} ions, the blue colour of the solution fades. As a result, the solution becomes colourless. The reaction may be written as :

$$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$$

$$Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$$

or

$$\underset{\text{(Blue colour)}}{Zn(s) + Cu^{2+}(aq)} \longrightarrow \underset{\text{(Colourless)}}{Zn^{2+}(aq)} + Cu(s)$$

or $CuSO_4(aq) + Zn(s) \longrightarrow ZnSO_4(aq) + Cu(s)$

REMEMBER

- **All metals which are placed above hydrogen in the activity series can lose electrons more readily than hydrogen. These are called *metals more reactive than hydrogen.***

  For example, potassium, sodium, calcium, magnesium, aluminium, zinc, iron, tin, lead etc. are **more active** than hydrogen.
- **On the other hand, all metals which are placed below hydrogen in the reactivity series lose electrons less readily than hydrogen and hence they are regarded as *metals less reactive than hydrogen.*** For example, copper, mercury, silver and gold are **less active metals.**

However, copper cannot displace zinc from $ZnSO_4$.

$$Cu(s) + ZnSO_4(aq) \longrightarrow \text{No reaction}$$

This is due to the fact that copper is less reactive than zinc. Therefore, copper cannot lose electrons in preference to zinc and the above reaction cannot occur.

USEFULNESS OF ACTIVITY SERIES

The activity series is very useful and it gives the following informations:

(*i*) The metal which is higher in the activity series is more reactive than the other. **Potassium is most reactive and platinum is least reactive.**

(*ii*) The metals which have been placed above hydrogen are more reactive than hydrogen and these can displace hydrogen from its compounds like water and acids to liberate hydrogen gas.

(*iii*) The metals which are placed below hydrogen are less reactive than hydrogen and these cannot displace hydrogen from its compounds like water and acids.

(*iv*) A more reactive metal (placed higher in the activity series) can displace the less reactive metal from its solution.

(*v*) Metals at the top of the series are very reactive and, therefore, they do not occur free in nature. The metals at the bottom of the series are least reactive and, therefore, they normally occur free in nature. For example, gold, the last element of the series is found almost as free element.

CHEMICAL PROPERTIES OF NON-METALS