Reactivity series

Metals can be put in a reactivity series based on their reactions with water and dilute hydrochloric/sulfuric acid or by using competition/displacement reactions.

	Reaction with water	Reaction with dilute HCl/H_2SO_4
Potassium	Reacts violently with cold water $2K + 2H_2O \rightarrow 2KOH + H_2$	Explosive reaction $2K + 2HCl \rightarrow 2KCl + H_2$
Sodium	Reacts vigorously with cold water $2Na + 2H_2O \rightarrow 2NaOH + H_2$	Explosive reaction $2Na + 2HCl \rightarrow 2NaCl + H_2$
Calcium	Reacts quickly with cold water $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$	Very vigorous reaction $Ca + 2HCl \rightarrow CaCl_2 + H_2$
Magnesium	Reacts very slowly with cold water but reacts vigorously when heated with steam $Mg + H_2O \rightarrow MgO + H_2$	Vigorous reaction $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
Zinc	No reaction with hot or cold water. Reacts when heated to red heat in steam $Zn + H_2O \rightarrow ZnO + H_2$	Reacts with acids $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
Iron	No reaction with hot or cold water. Reacts when heated to red heat in steam $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$	Reacts with acids $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$
(hydrogen)		
Copper	No reaction with water or steam.	No reaction

Metals will react with water to form the hydroxide and hydrogen and with steam to form the oxide and hydrogen. The reaction with steam is a competition reaction and the metal takes the oxygen away from the hydrogen.

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Potassium
Sodium
Lithium
Calcium
Magnesium
Aluminium
(carbon)
Zinc
Iron
(hydrogen)
Copper
Silver
Gold

Displacement reactions

A metal higher in the reactivity series will reduce the oxide of a metal lower in the reactivity series, e.g. $Mg + CuO \rightarrow MgO + Cu$

competition/displacement reaction

A more reactive metal will displace a less reactive metal from solution:

$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

Observations: pink-brown metal formed, blue colour fades, piece of Mg gets smaller, gets warm

Ionic equation: $Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$

The more reactive a metal is, the greater tendency it has to form its positive ion, thus Mg forms a positive ion more readily than Cu does.

The magnesium is more reactive – it is a stronger reducing agent than Cu and will therefore reduce the Cu^{2+} ion to Cu.

Metals higher up the series are stronger reducing agents than metals lower in the series. Thus metals higher in the series will give electrons to the ions of metals lower in the series.

Redox

Oxidation – gain of oxygen e.g. $CuO + Mg \rightarrow MgO + Cu$ Mg is oxidised since it gains O

Reduction – loss of oxygen e.g. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Iron in Fe_2O_3 is reduced since it loses oxygen

Oxidation – loss of electrons

$Zn \rightarrow Zn^{2+} + 2e^-$ Zn oxidised

$2Cl^- \rightarrow Cl_2 + 2e^-$ Cl^- oxidised

total charge and total number of atoms must balance on each side

Reduction – gain of electrons $Cu^{2+} + 2e^- \rightarrow Cu$ Cu^{2+} reduced

An **oxidising agent** oxidises other species – it is an electron acceptor and removes electrons from other species. The oxidising agent gets reduced in the process.

A **reducing agent** reduces other species – it is an electron donor and gives electrons to other species. The reducing agent gets oxidised in the process.

Rusting

Rusting is a redox reaction. The iron is oxidised to form hydrated iron(III) oxide.

Both OXYGEN and WATER are required to cause rust. If we can keep one (or both) of these away from the iron, we can prevent rust.

Barrier Methods: Painting, coating with plastic and oiling/greasing steel prevent rusting by excluding oxygen and water. If these coatings are scratched the iron/steel underneath will rust.

Galvanising: coating iron/steel with zinc. The zinc is more reactive than the iron and therefore zinc corrodes rather than the iron. Even if the zinc coating is scratched, the iron does not rust. Zinc is oxidised in preference to iron and the electrons produced prevent positive iron ions forming.

Sacrificial protection

Magnesium blocks are often bolted onto the underside of a ship to prevent the hull from rusting. Magnesium is more reactive than iron and is oxidised in preference to the iron. The magnesium must be replaced periodically. Galvanising is also a form of sacrificial protection.