2.3 Metals

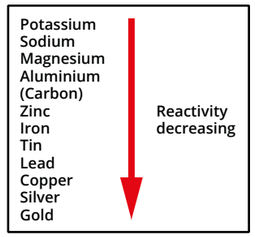
Metal ores:

Ores are minerals found in the Earth's crust. They contain metal compounds, from which metals can be extracted.

Name of ore	Metal compound
rock salt	sodium chloride
bauxite	aluminium oxide

Reactivity series:

The method used to extract metals from their ores depends on the reactivity of the metal. The reactivity series allows us to predict how metals will react.



Gold and silver are examples of metals that are found native. The most reactive metals are extracted by electrolysis, while those towards the middle of the reactivity series can be chemically reduced.

Displacement and competition reactions:

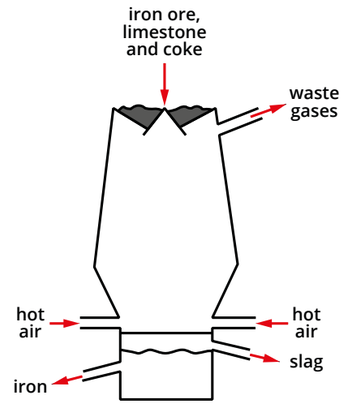
The relative reactivity of metals can be demonstrated by displacement reactions. A more reactive metal will displace a less reactive metal from a solution of one of its salts.

iron + copper(II) chloride → iron chloride + copper

During a competition reaction, a more reactive metal will remove oxygen from the oxide of a less reactive metal when a mixture of the two is heated. An example of this is the thermit reaction used in the rail industry to weld rails together on a track.

iron(III) oxide + aluminium oxide → iron + aluminium oxide

The blast furnace:



Raw materials

Iron ore: *source of iron*.

Coke: *as a fuel and to produce carbon monoxide for the reduction*.

Limestone: *to remove impurities (slag formation).*

Hot air: *provides oxygen so that coke can burn.*

Oxygen from the hot air reacts with carbon (coke) to form carbon monoxide. This is an exothermic reaction and heats the furnace.

$$2C + O_2 \rightarrow 2CO$$

Carbon monoxide then reacts with iron(III) oxide to give iron.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Limestone decomposes thermally to form calcium oxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

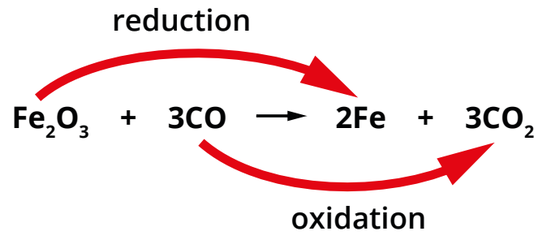
Calcium reacts with silicon dioxide (sand) to form slag.

$$CaO + SiO_2 \rightarrow CaSiO_3$$

This is an example of a neutralisation reaction.
The process in the blast furnace is continuous, with new raw materials added and products removed all the time due to the time and cost associated with getting the furnace up to temperature.

Oxidation and reduction:

Oxidation is the gain of oxygen whilst reduction is the loss of oxygen. For the reaction that happens in the blast furnace, the iron(III) oxide is reduced whilst the carbon monoxide is oxidised.



Transition metals:

Transition metals are found in the centre of the Periodic Table and they display the typical metallic properties of high melting and boiling points, malleability, high density, good electrical and thermal conductivity. Many transition metals are useful catalysts - e.g. iron in the manufacture of ammonia, platinum in catalytic converters. They can form more than one type of ion, e.g. Fe^{2+}/Fe^{3+} and their compounds are often coloured.

Ion	Colour of compounds/ solutions
Fe^{2+}	pale green
Fe^{3+}	brown
Cu^{2+}	blue

We can test for the presence of transition metal ions by using a solution of sodium hydroxide.

$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$

blue precipitate

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

green precipitate

$Fe^{3+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_3(s)$

orange/brown precipitate

Alloys:

An alloy is a mixture made by mixing molten metals. Its properties can be modified by changing its composition. Steel is much harder and stronger than iron and is therefore more useful. Different types of steel are made by varying the carbon content. For example, mild steel (iron plus 0.15-0.3% carbon) is malleable, ductile and easily shaped, whilst high carbon steel (iron plus 0.7-1.5% carbon) is harder but more brittle.