Reactivity series of metals worksheet

A focus on Aluminium and Iron

Reactivity Series

Have you ever wondered why gold, silver and platinum are used in jewellery and yet metals such as zinc and magnesium, are not? It is to do with their reactivity. Gold, silver and platinum are chemically very unreactive and retain their shiny appearance. Zinc and magnesium however react with the oxygen in the air and lose their shiny appearance—not a very useful property for jewellery!

The metal elements can be arranged in a list according to their reactivity; that is, how easily they react with other substances. The most reactive metals are at the top of the list and the least reactive at the bottom. This is called the **reactivity (or activity) series.**

Things to remember about the reactivity series

1. The more reactive a metal, the more it forms compounds. So, only copper, gold and silver are ever found as elements in the Earth's crust. The other metals are always found as compounds.
2. The more reactive a metal, the more stable its compounds. A stable compound is difficult to breakdown or decompose, because the bonds holding it together are very strong.

This last property affects the decision on how a metal is obtained from its ore. The processing method depends on the reactivity of the metal, as shown in the table.

Metal			Method of Processing		
Sodium Calcium Magnesium Aluminium	**Metals more reactive**	**Ores more difficult to decompose**	Electrolysis	**Method of processing more powerful**	**Method of processing more expensive**
Zinc Iron Tin* Lead*			Heating with carbon or carbon monoxide		
Copper*			Roasting in air		
Silver Gold			Occurs naturally as elements		

Note.* Although copper, tin and lead are initially refined using other methods, electrolysis can be used for further purifi cation of all three metals.

More about aluminium

Aluminium is the most abundant metal in the Earth's crust. Its main ore is bauxite, which is a general term for a rock composed of hydrated aluminium oxides together with impurities of iron oxides. These impurities make it reddish brown.

The steps in obtaining aluminium are listed below.

1. Geologists test bauxite to determine if aluminium content is high enough to warrant mining.
2. The bauxite is mined.
3. The bauxite is taken from the mine to the processing plant where it is treated to remove the impurities. The result is white aluminium oxide or alumina.
4. The alumina is taken to another plant for further processing by electrolysis. Aluminium is formed at the negative electrode. It drops to the bottom of the tank as molten metal. Oxygen gas is formed as a by-product at the positive electrode.
5. The aluminium metal is made into sheets and blocks, and sold to other industries.
6. It is used to make soft drink cans, cooking foil, saucepans, television aerials, aeroplanes and even space rockets.

In Step 4, the aluminium is obtained by electrolysis. This is carried out in a huge steel tank, as shown below.

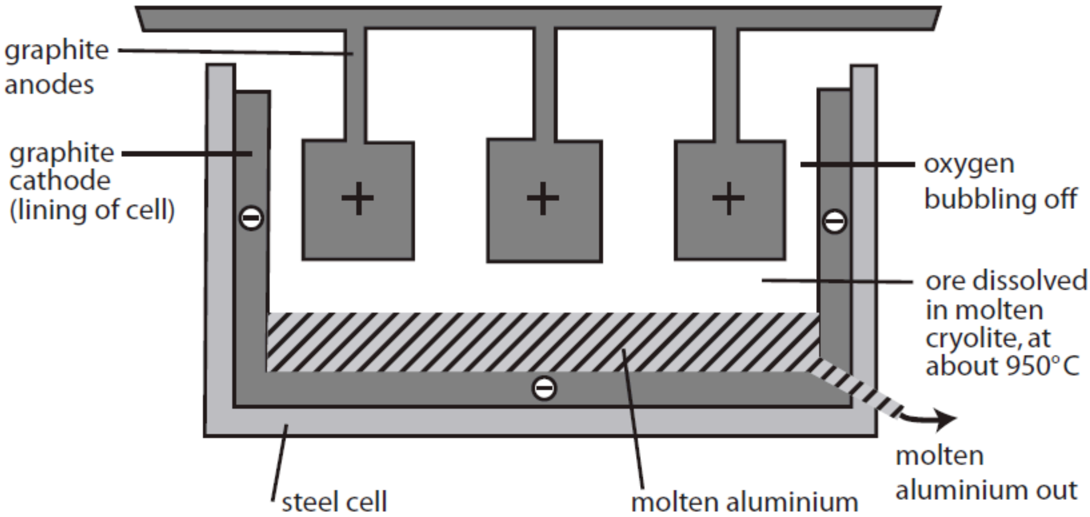

Figure 1. Electrolysis of aluminium

Source: copyright © Oxford University Press from Coordinated Science: Chemistry by R Gallagher and P Ingram (OUP, 1989), reprinted by permission of Oxford University Press.

Pure alumina melts at 2045°C. It would be expensive and dangerous to keep the tank at this temperature. Instead, the alumina is dissolved in another aluminium compound, cryolite, with a much lower melting point.

More about iron

Iron is the second-most abundant metal in the Earth's crust. To process it, three substances are needed.

1. Iron ore. The chief ore is called haematite. It is mainly iron oxide, Fe2O3 (s) mixed with sand. Australia is one of the world's largest iron-ore producers.
2. Limestone. This is a relatively common rock. It is mainly calcium carbonate, CaCO3 (s).
3. Coke. This is made from coal, and is nearly pure carbon, C (s).

These three substances are mixed together to give a mixture called charge. The charge is heated in a tall oven called a blast furnace. Several reactions take place and finally liquid iron is produced.

In the blast furnace

A blast furnace is like a giant chimney, at least 30 metres tall. It is made of steel and lined with fireproof bricks. The charge is added through the top and hot air is blasted through the bottom. This makes the charge glow white hot, and provides the energy for the reactions below to take place.

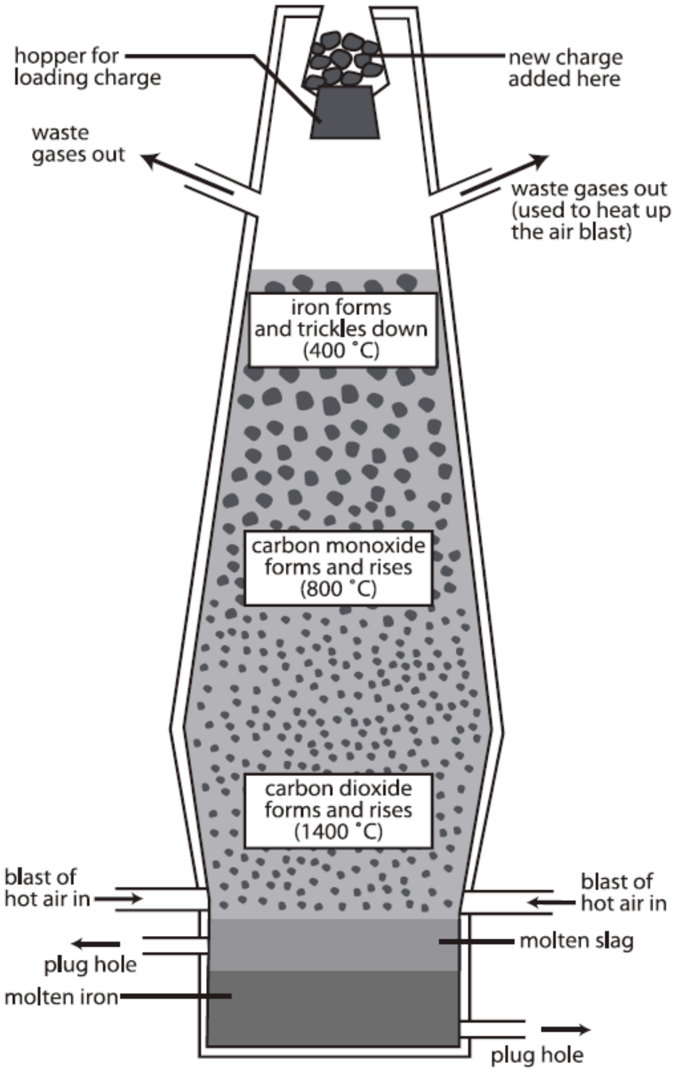

Figure 2. Blast furnace diagram

Source: copyright © Oxford University Press from Coordinated Science: Chemistry by R Gallagher and P Ingram (OUP, 1989), reprinted by permission of Oxford University Press.

1. The coke reacts with oxygen in the hot air to produce carbon dioxide
2. The limestone breaks down to produce calcium oxide and carbon dioxide
3. The carbon dioxide reacts with more code, giving carbon monoxide
4. Carbon monoxide reacts with the iron oxide, giving liquid iron, which trickles to the bottom of the furnace
5. Calcium oxide from Step 2, reacts with the sand in the iron ore to produce calcium silicate, or slag.

The slag runs down the furnace and floats on the iron.

The slag and the iron are drained from the bottom of the furnace.

The slag is left to solidify and is then sold, mostly for road building. Some of the iron is left to solidify in moulds, or casts. It is called cast iron. Containing impurities such as carbon, it is not only very hard but also very brittle, because it snaps under strain. It is used only for things like gas cylinders, railings and storage tanks that are not likely to get bent during use.

Most of the iron from the blast furnace is turned into steel, while still hot. Steel is an alloy of iron. There are many different types of steel. Below are just three of them.

Name	Contains	Special Property	Uses
Mild steel	99.5% Fe, 0.5% C	Hard, but easy to work	Buildings, car bodies
Hard steel	99% Fe, 15 C	Very hard	Blades for cutting tools
Duriron	84% Fe, 1% C, 15% Si	Resistant to acids	Tanks for pipes in chemical factories

Reactivity series of metals worksheet

Chemical Reactions

Complete and balance the chemical reactions for the word equations, or write the word equations for the balanced chemical equations. The following five reactions are the steps in making iron in a blast furnace.

Reaction 1	Coke (carbon) + oxygen -> carbon dioxide __________ $_{(s)}$ + __________ $_{(g)}$ -> __________ $_{(g)}$
Reaction 2	__________ -> __________ -> __________ $CaCO_{3\,(s)}$ -> $CaO_{(s)}$ -> $CO_{2\,(g)}$
Reaction 3	Coke (carbon) + carbon dioxide -> carbon monoxide __________ $_{(s)}$ + __________ $_{(g)}$ -> __________ $_{(g)}$
Reaction 4	Carbon monoxide + iron (III) oxide -> iron + carbon dioxide __________ $_{(g)}$ + __________ $_{(s)}$ -> __________ $_{(s)}$ + __________ $_{(g)}$
Reaction 5	__________ + __________ -> __________ $CaO_{(s)}$ + $SiO_{2\,(s)}$ -> $CaSiO_{3\,(l)}$

This information sheet is an extract of the publication The Science of Mining, published by the Queensland Resources Council and the Queensland Department of Natural Resources, Mines and Energy, 2004.