



## How do Fireworks Work?



Read the information below and then answer the questions in your workbook.

Fireworks were first made in China 2000 years ago. They were a very simple bamboo tube containing gunpowder and a basic fuse. Fireworks were used in religious ceremonies and are still used at celebrations such as weddings and birthdays today. The largest firework ever created was made in Japan and was half a tonne in weight and when it exploded it was 1 km across. The explosive part of a firework is gunpowder. Gunpowder contains 75% potassium nitrate ( $\text{KNO}_3$ ), 15% carbon and 10% sulfur. These react together when heat is applied. The  $\text{KNO}_3$  acts as an oxidiser which means it provides oxygen to the reaction. The carbon (in the form of charcoal or sugar) acts as the fuel providing the energy. The sulphur moderates the reaction and controls how it burns. The amount of sulfur can alter how explosive the gunpowder is. Another type of gunpowder is called 'flash powder' which contains aluminium and potassium perchlorate. This is very powerful and is used to make the fireworks that are used in public displays.

There are three main types of fireworks:

- Firecrackers: Noisy explosions that make a loud ground-based bang.
- Sparklers: Non-explosive, slow burning and hand held.
- Aerial Shells: Have two series of explosions and the second one explodes in the air.



In firecrackers, the fuse sets the gunpowder alight which burns and reacts producing potassium sulfide and the gases nitrogen and carbon dioxide. These are produced from the potassium nitrate, carbon and sulphur in the gunpowder. These gases build up and expand which creates a huge amount of pressure inside the tube which blows it apart, creating the bang.

In a simple sparkler, potassium perchlorate, dextrin and water are mixed together and pasted onto a metal stick. This is then dipped in aluminium flakes, with other chemicals added to make different colours. The gunpowder is in such proportions that it burns slowly and doesn't explode, which makes them safe to hold in your hand.

The aerial shells are a lot more complicated. They contain two sections where the first part has a fuse that is lit which ignites the first rocket. This heat causes the gases to be made like in a firecracker except in this case there is a small hole in the bottom of the rocket that lets the gas escape. The stream of high pressure gases propels the second half of the rocket upwards instead of exploding. Inside the second half are pellets called stars. These stars are small compartments that contain different metal salts and metals which explode into different colours. The order the stars explode at give different patterns like flowers or spheres or wheels. By having the stars as pellets it stops them from burning too fast and allows them to fall before exploding which creates the spreading pattern that you see. The size of the pellets causes them to explode at different times. Small ones burst first and then the second set of explosions are the bigger pellets. That's how you get rings of explosions.

There are different descriptions for the way the fireworks look in the sky which are determined by the size, shape and layout of pellets inside the second rocket shell. Here are a few of the possible styles:

- Palm: Solid cylinders travel out and down like palm fronds.
- Willow: Lots of charcoal so they burn for a long time and fall like branches of a willow tree, they sometimes even touch the ground.
- Serpentine: Bursts of small tubes in random patterns which explode at the end.

To the left is a list of the salts and metals that are commonly used and the colours that they produce.

Colour	Substances Involved
red	$\text{Li}_2\text{CO}_3$ and $\text{SrCO}_3$ and $\text{LiCl}$
orange	$\text{CaCl}_2$ and $\text{CaSO}_4$
gold	iron, charcoal and lampblack
yellow	$\text{NaNO}_3$ and $\text{Na}_3\text{AlF}_6$ and $\text{NaCl}$
white	magnesium, aluminium and $\text{BaO}$
green	$\text{BaCl}_2$ and $\text{BaSO}_4$
blue	$\text{CuCl}_2$
purple	$\text{KCl}$ or a mixture of $\text{SrCO}_3$ and $\text{CuCl}_2$
silver	aluminium, titanium, magnesium