

“Xtreme” Chemical Changes

When you see a colourful fireworks display, you probably don't think about chemistry. But it is chemistry that gives us the special effects of bursts of colour, flashes, and sound (Table 1).

Table 1 Some Chemicals Used for Special Effects

Materials	Special effects
magnesium metal	white flame
sodium oxalate	yellow flame
barium chlorate	green flame
cesium (II) sulphate	blue flame
strontium carbonate	red flame
iron filings and charcoal	gold sparks
potassium benzoate	whistle effect
potassium nitrate and sulfur	white smoke
potassium perchlorate, sulfur, and aluminum	flash and bang

The creators of fireworks displays are called pyrotechnics technicians. They are specialists in controlled explosions and must keep chemistry in mind at all times.

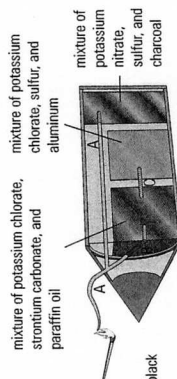
Each firework explosion is a carefully controlled series of chemical changes that occur at just the right times. These chemical changes produce large amounts of heat in short periods of time.

Chemistry and Fireworks

A typical firework contains a fuel, a source of oxygen (called an oxidizer), a fuse (a source of heat to start the reaction), and a colour producer. Suppose the technicians have the job of making a firework that will rise 50 m and then produce a red burst of fire, followed by a loud bang and a flash. The technician would have to make, by hand, three different explosive mixtures: one to lift the firework shell into the air, and one for each of the special effects (Figure 1).

The first and the most dangerous step is mixing the ingredients. The oxidizer is the main component, making up anywhere from 34% to 68% of the material in the firework. Typical oxidizers are potassium nitrate (KNO_3), potassium chlorate (KClO_3), and ammonium perchlorate (NH_4ClO_4). When the oxidizer in the fuel reacts with sulfur or aluminum, it creates great amounts of heat, as well as a “bang” and flashes of light. The bang comes from the rapidly expanding gases that are being produced.

Each mixture also contains binders such as paraffin oil and red gum. Binders act as a fuel and also hold the mixture together. Magnesium metal, or any of the metallic salts in Table 1, is added to



- 1 The technician lights the first fast-burning fuse (A), which causes an explosion that launches the shell into the air as the black powder explodes.
- 2 Fuse A also lights a slow-burning fuse (B) which ignites a mixture that produces a red burst when the shell is high in the air.
- 3 The red explosion lights another slow-burning fuse (C) which ignites a mixture that produces a final flash and loud bang.

Figure 1
A fireworks shell

produce a specific colour. It is very important to understand how each chemical will react with others. Pyrotechnic technicians must be careful in choosing ingredients so that the oxidizer will not react with the metallic salt while it is in storage. If they were to react, there could be a dangerous explosion. Finally, the technician wraps each mixture in a cardboard package and links the packages together with fuses.

Did You Know?

Watching fireworks on Canada Day is an annual tradition for many Canadians. However, many people do not realize how dangerous fireworks can be, particularly when children handle them. Thousands of injuries occur every year as a result of improperly using fireworks. Data released from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) report suggests that following proper safety procedures would prevent most of these injuries (“Injuries Associated with Fireworks,” Health Canada, 1999).

Work the Web

Go to www.nelson.science.com and follow the links from *Science 9: Concepts and Connections*, 1.6. Find out which salts are used to make each of the following colours: red, orange, gold, yellow, electric white, green, blue, purple, and silver. What do pyrotechnic technicians need to get pure colours?

Challenge

- 1 In recent years, an indoor or “cold” firework has been developed. New colours have also been developed as the research in colour technology advances. Could you market either of these new “products”?
- 2 Could you create a 3-D, cross-sectional model of a “cold” firework that would show the elements of design that differ from a regular firework?
- 3 Many elements are used to create fireworks. Could the scientist who discovered one of these elements be your famous scientist?

Understanding Concepts

1. Explain how fireworks give off bursts of light and sound.
2. What does an oxidizer do?
3. Why are oxidizers so dangerous?