LEVELED BOOK • Q

Fireworks

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Introduction

The celebration began on a tiny island in the Pacific Ocean. Then, as the Earth turned, midnight arrived in Sydney, Australia. Rings of fire exploded over the city's famous opera house. Firecrackers popped in Hong Kong. Skyrockets flew over Bombay, the Egyptian pyramids, and Moscow. The Eiffel Tower shot bright sparks from its top like foam from a champagne bottle. Mexico City and Chicago were lit red, gold, and green. All around the world, fireworks welcomed the year 2000.

Fireworks combine science and art to create some of the most beautiful displays ever seen. The making and launching of fireworks is called **pyrotechnics** (PIE-roe-TECK-nicks). In most cases, this dangerous craft is still performed by hand. Families pass down secret fireworks-making skills and formulas from generation to generation.

Fireworks at the Statue of Liberty

History of Fireworks

No one is sure when fireworks first shot into the sky. But we do know that it happened in China over 1,000 years ago. Legend says that a Chinese cook accidentally created **gunpowder** by mixing ingredients in his kitchen.

A Chinese soldier lighting a bamboo tube packed with explosive powder

The Chinese packed this explosive black powder into bamboo or paper tubes. The powder shot fire out of the tubes, much like Roman candles do today. Someone discovered that if a wooden carving was placed on top of the gunpowder, the carving would shoot into the sky. One carving of a dragon even had gunpowder in its mouth. The dragon seemed to spray fire as it flew.

The secret of gunpowder passed to Arabs and then on to Europe. But it was mostly used in weapons to fire cannons and guns. Often, armies shot their cannons to celebrate a victory. Different countries began mixing certain chemicals with the gunpowder to create brighter flashes, louder bangs, and color. The Italians soon became famous for their colorful displays. The Grucci family, now living in the United States, continues the Italian tradition of fireworks mastery.

A Grucci firework display at the Aladdin Hotel in Las Vegas, Nevada

How Fireworks Are Made

All fireworks start with gunpowder. To create colors, fireworks makers combine special chemicals with the gunpowder. These chemicals burn with different-colored flames. Surprisingly, most of these chemicals are kinds of salt. They may also mix flakes of metal with the gunpowder. When the powder explodes, these flakes become glowing hot, creating a shower of sparks.

Different chemicals burn with different colors. Copper, the metal in pennies, burns blue-green. The same color change happens, only much more slowly, to pennies when they turn green. This is why the Statue of Liberty, which is made of copper, looks green. The chart below lists some other chemicals and the colors they produce.

Fireworks Chemicals

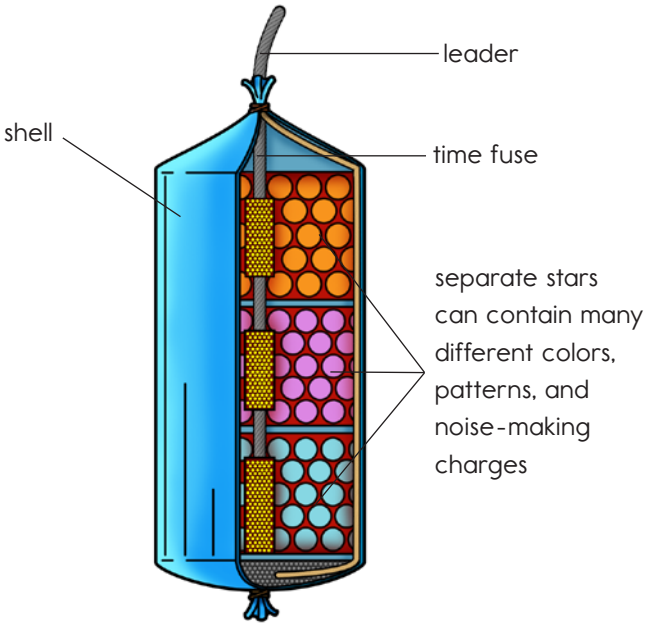
Chemical	Effect
Copper salts	Blue
Strontium salts	Red
Sodium	Yellow
Barium nitrate	Green
Potassium perchlorate	Makes loud booms

Fireworks cause sound because the intense heat expands the air around the firework. The air is pushed outward in a wave. Your ear picks up this wave as a loud sound. Sometimes your chest and feet can also feel the wave vibrating. This is the same way that lightning creates thunder.

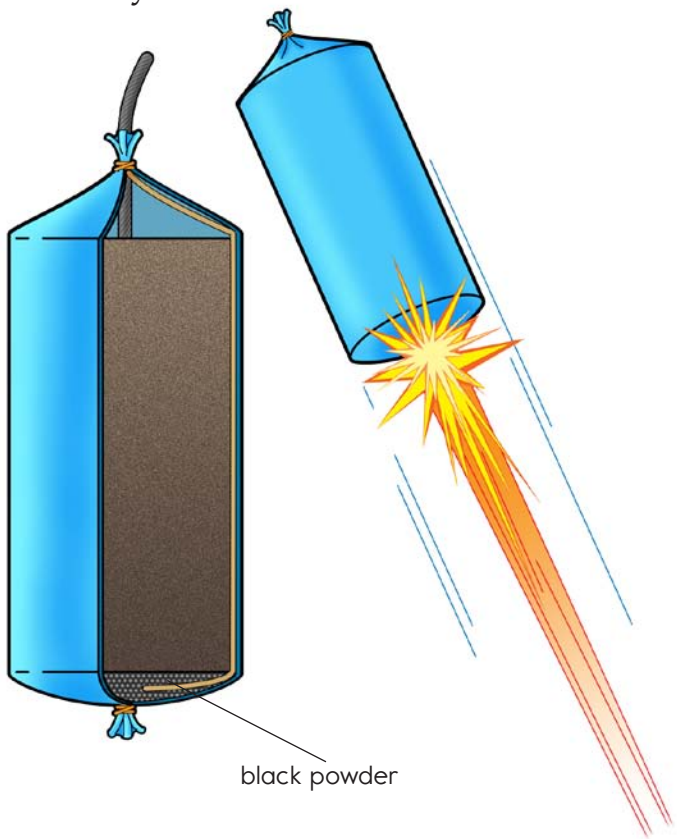
The whistles come from the hot gasses combustion creates. Fireworks makers put tiny paper whistles inside the shells. When the stars combust, the hot gasses "blow" the whistles, creating the sound.

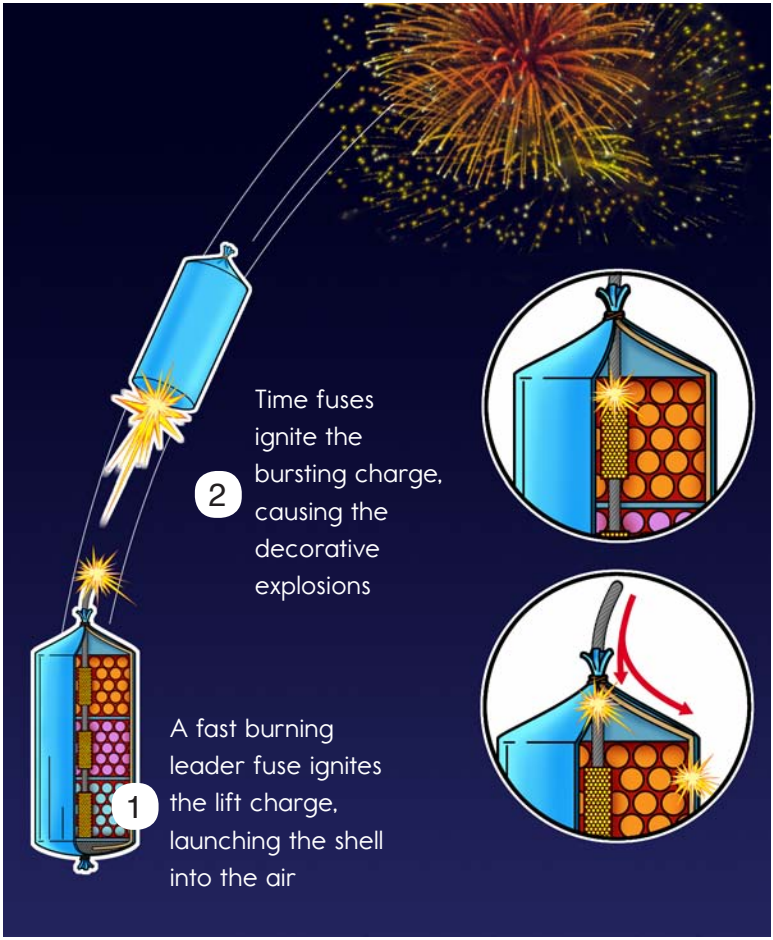
Fireworks makers roll the colored or sparkling gunpowder into small balls called stars. Some stars are a single color, while others are layered with different colors. They pack the stars inside stiff paper shells. Hundreds of stars can fit in one shell.

If the fireworks maker packs the stars in a globe shape, the firework will explode in a globe of fire. If he or she packs it in a star shape, it will explode into a star. If he or she packs it in a smiley-face shape, it will explode into a smiley face.

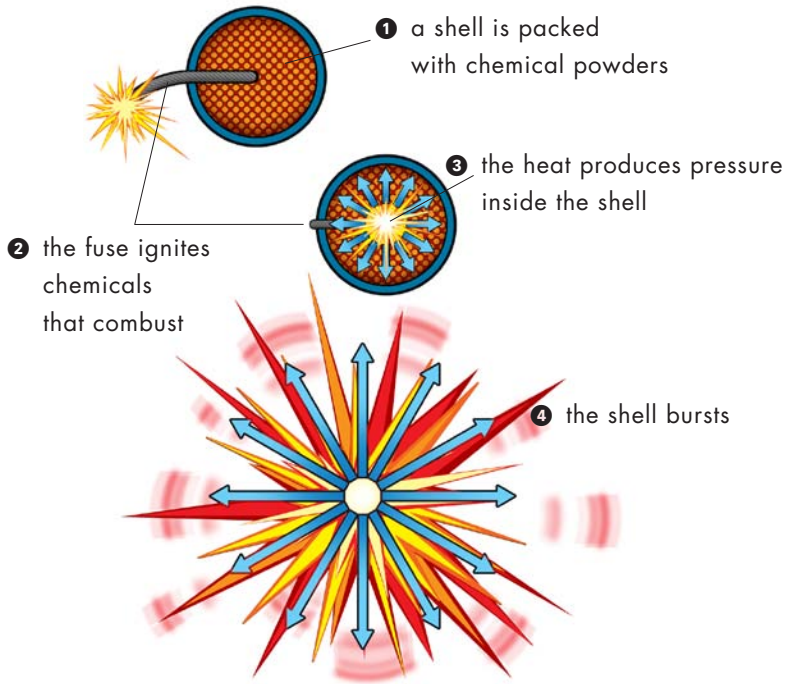


Sometimes each star has its own paper tube. The tubes force the stars to shoot away from the main firework in streaks of light. And sometimes the shell is packed solid with powder that creates a single flash and a huge bang, called a **salute**. At the center of every shape is a ball of gunpowder called a **bursting charge**. The bursting charge explodes like a firecracker. It lights the stars and sends them out into the sky.





The last part of the shell is the **lift charge**. This is a container of powder that will shoot the entire shell high into the sky. Usually, the lift charge is ordinary gunpowder. But sometimes it creates a streak of color as the firework rises.



Do You Know?

Combustion is the scientific term for burning or exploding. Almost all combustion requires oxygen. A flame under a glass dome will soon go out when it uses up all the oxygen. Gunpowder has oxygen right in it, which makes it extra flammable. Combustion also makes the air around it expand, or grow larger. When gunpowder combusts inside a shell, the air inside the shell expands, forcing the shell to burst open.

Each firework has a special series of fuses that control when the firework explodes. The first fuse, called a **leader**, lights the lift charge, sending the firework flying. The lift charge then lights a **time fuse**. The material of the time fuse burns at a steady rate. The fireworks makers know just how long to cut the fuse so it burns until the shell is at the right height. The time fuse then sets off the bursting charge. Sometimes a shell will have smaller shells inside it. In that case, the bursting charge lights more time fuses. These will set off the smaller shells once they're the right distance away from the main shell.

Loading shells with black powder

Creating the Show

It can take up to two days to set up a twenty-minute fireworks show. First, everything must be designed on a diagram. Each shell will be fired in a specific order, and everything must be set up so that each one goes in turn.

Assembling fireworks

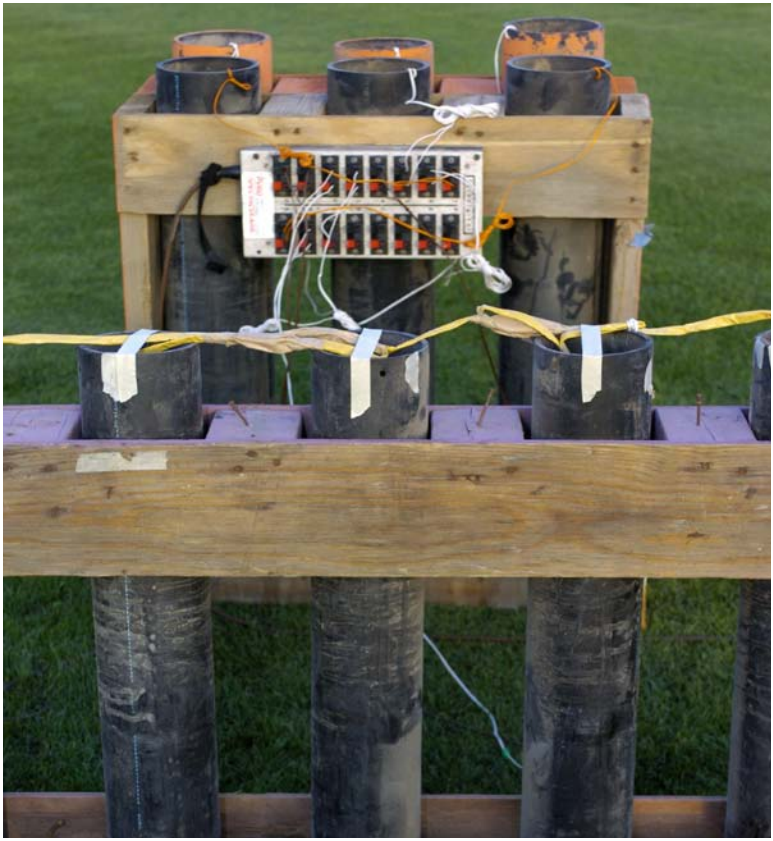
Workers begin by building batteries, or wooden racks. If the show is near water, the batteries are put on a boat, safely away from the crowd. Some batteries sit on the sides of buildings, such as the Washington Monument or the Eiffel Tower. Each battery holds a group of metal tubes called **mortars**. Each mortar holds one shell. It shoots the shell the way a cannon shoots a cannonball. All the mortars are numbered according to the diagram.

The finished shells are also numbered. When they arrive on the site, they are carefully placed in the correct mortars. Workers connect the shells' leaders, or main fuses, to electrical matches. And each electric match is connected to the firing panel, which is the control panel for the whole show. In the past, the fireworks maker had to push buttons on the panel to get each match to light. He or she had to pay close attention in order to avoid mistakes. Today, most firing panels are computerized.

Loading a 10-inch shell into a mortar

Everyone checks the fuse connections, the placement of the shells and mortars, and the firing order. Then they check them again. A mistake could set the fireworks off incorrectly, ruining the show and possibly even injuring people.

Wiring the circuit board



Mortars loaded with shells and wired

On the night of the show, the crew puts on helmets, goggles, and fireproof clothing. This gear protects the workers from falling sparks, ash, and paper. The workers stay close by to make sure nothing goes wrong. But once the switch is flipped, the computer takes over and begins lighting matches. The show explodes in a shower of color and sound.

Computer firing panels have become so precise that fireworks can be set to music. A designer chooses a favorite piece of music. The designer listens to the music over and over, imagining where to put a purple fountain, a golden blast, or flashes and crashes. The firing panel is programmed to light the shells with the music, using the timer on the CD or computer file.

Millennium celebration, Washington, D.C.

Fireworks Safety

Fireworks explode, and explosions can be deadly. Fireworks injure about 10,000 people every year in the United States alone. Firecrackers can blow off a hand. Sparklers can send a glowing-hot spark of metal into someone's eye. And illegally stored fireworks can cause devastating fires. In addition, fireworks cause smoke and noise, and they often terrify animals. Many states have laws against using fireworks. Those laws exist to protect people. Using, storing, or selling illegal fireworks can lead to arrest, fines, or even jail. It is best to leave fireworks to the trained professionals.

Fireworks explosion, Lima, Peru

An attention-getting way to sell fireworks

If you do watch fireworks, be sure to follow these safety tips:

- Always watch from a safe distance, and never approach the fireworks.
- Never pick up debris from fireworks. It may still contain explosive gunpowder.
- Bring ear protection. Long exposure to loud noises can damage your hearing.
- Never, ever light fireworks yourself. If consumer fireworks are legal in your state, always have an adult light them.
- Have water handy to put out any fires or sparks.

Glossary

bursting charge	gunpowder that lights the stars and bursts the firework shell (p. 13)
gunpowder	explosive black powder used in fireworks and weapons (p. 6)
leader	the fuse that connects the lift charge to an electric match (p. 16)
lift charge	gunpowder that shoots the firework shell into the sky (p. 14)
mortars	metal tubes that hold fireworks shells and shoot them into the sky (p. 17)
pyrotechnics	the making and lighting of fireworks and other fire effects (p. 5)
salute	a single bright flash and loud bang (p. 13)
time fuse	the fuse that connects the lift charge to the bursting charge (p. 16)

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