Teacher Guide
The Science of Cannons

Grade Level: 4th – 8th Grade
Time Requirement: 30 - 45 minutes

Introduction
When a cannon is fired, it relies on various scientific principles, including the Law of Conservation of Energy and chemical reactions. The **Law of Conservation of Energy** states that energy is neither created nor destroyed; it is only converted from one form to another. A **chemical reaction**, also called a chemical change, occurs when one or more substances change into completely different ones. In this activity, students will investigate chemical reactions and energy conversions during cannon firing as they create film canister cannons with Alka Seltzer and water.

Required Materials
- Alka Seltzer Tablets (1 Box of 72 Tablets)
- 35mm Film Canisters (12)
- Water (warm and cool)

Science Standards
- 4.8(A) investigate and identify the transfer of energy by objects in motion, waves in water, and sound
- 6.6(E) identify the formation of a new substance by using the evidence of a possible chemical change, including production of a gas, change in thermal energy, production of a precipitate, and color change
- 6.8(A) compare and contrast gravitational, elastic, and chemical potential energies with kinetic energy
- 6.8(B) describe how energy is conserved through transfers and transformations in systems...
- 7.6(C) distinguish between physical and chemical changes in matter
- 8.6(E) investigate how mass is conserved in chemical reactions and relate conservation of mass to the rearrangement of atoms using chemical equations, including photosynthesis

Objectives
- Identify the different forms of energy present before, during, and after the firing of a cannon.
- Compare the energy conversions occurring during the firing of cannons at the Battle of the Alamo, as well as during the “firing” of the model cannons.
- Identify chemical reactions.

Historical Context

For hundreds of years, cannons were popular weapons used across the world. By the 1800s, most cannons were made from iron or bronze. They could shoot **projectiles** of various sizes and were named by the weight of their projectiles. For example, a cannon that shot six-pound cannonballs was called a six-pounder, and an 18-pounder shot a cannonball that weighed 18 pounds (that's slightly smaller than a cantaloupe!).

Cannons were muzzle-loading, meaning they were loaded from the front, open end. The loading process involved several steps and required multiple people. If the cannon had been previously fired, the first step would be to clean residue from inside the **barrel** using a tool called a **worm**. The next step was to ensure any burning cinders were extinguished. To do this, the **sponge** was dipped in water and pushed into the barrel. Next, the gunpowder was then pushed to the back of the barrel, or the **breach**, using a **rammer**. After the powder a wad of cloth or ball of string was inserted, and finally, the cannonball. A thin brass rod known as a **prick** was pushed through the **vent**, a small hole near the breach, making a small opening in the bag of gunpowder. Lastly, a gunpowder-filled turkey quill was placed into the vent, and it was lit, usually with a tool called a **linstock**.

At the Battle of the Alamo, the Texans had 24 cannons at their disposal. The largest cannon was the 18-pounder, stationed at the southwest corner of the fort. At the beginning of the Alamo Siege, this cannon was shot to refuse General Santa Anna's terms of surrender. Other cannons present included a 16-pounder, 12-pounder, and other smaller ones, including 6- and 4-pounders. These were placed throughout the Alamo fort, atop the walls and even in the Alamo Church.

After the Battle, many of the cannons were disabled through a method called **spiking**. This entailed driving a spike into the vent of the cannon or stopping up the muzzle with various objects. While many of the cannons used by the Texans during the Battle of the Alamo have been lost to history, some have been recovered and are undergoing restoration work. Most of the 11 cannons currently at the Alamo were found in 1852 buried on the homesite of Alamo garrison member Samuel A. Maverick. Selected to represent the garrison during the Constitutional Convention at Washington on the Brazos, Maverick left the fort prior to the final assault on March 6th. The Gibbs Hotel now sits upon the site of his former homestead.

These surviving cannons are important pieces in the Alamo Collection, because they have a direct link to the battle. To preserve them, the spikes and debris were removed along with rust, paint, and other surface buildup. After being cleaned, the cannons were coated with a range of substances to help prevent further damage. Today, the Alamo cannons are still undergoing conservation work at Texas A&M University in College Station, Texas, and eventually will be on display at the Alamo Visitor Center and Museum.

Background

The **Law of Conservation of Energy** states that energy is neither created nor destroyed; it is only converted from one form to another. While there are many forms of energy, they all fall into one of two categories– potential energy or kinetic energy. **Potential energy** is stored energy, often related to the chemical structure, position, or shape of an object. There are many types of potential energy, including chemical, elastic, and nuclear. **Kinetic energy** is energy related to the motion of objects, particles, and waves. Types of kinetic energy include mechanical, thermal, and sound. When firing a cannon, we can identify multiple forms of energy as well as the conversions that occur between them.

Firing a cannon begins with inserting gunpowder into the barrel. Gunpowder is composed of various substances, usually charcoal, saltpeter, and sulfur, which contain a high amount of **chemical potential energy.** This chemical energy is stored in the chemical bonds that exist between the atoms of the gunpowder. Next, a cannonball is inserted into the barrel (**gravitational potential energy**), and the gunpowder is ignited through the top of the cannon. When gunpowder is ignited, the chemical bonds within are broken in a series of chemical reactions**.**

A **chemical reaction**, also called a chemical change, occurs when one or more substances change into completely different ones. Their identities can change because, during the chemical reaction, the atoms of the original substances are rearranged to form new ones. While it can seem that new materials appear from nothing or disappear completely, nothing is created nor destroyed during a chemical reaction –just reconfigured. It can be difficult to identify when a chemical reaction occurs, but there are three things to look

for: changes in color, formation of gas or bubbles, and the formation of a **precipitate**, which is a solid that forms when two liquid solutions combine.

When the gunpowder is ignited and the chemical reactions occur, they produce a lot of **heat energy**, as well as nitrogen gas (N_2) and carbon dioxide gas (CO_2). The gases expand and create intense pressure within the cannon, which propels the cannonball forward with high **kinetic energy.** Additionally, some potential energy is also converted to **sound energy**, which we hear as a loud boom.

Procedures

Teacher Notes

The lab procedures below are focused on student exploration. Students create a plan, test their ideas, and adjust as necessary. A standard procedure is also outlined if needed. **Ensure students wear goggles, gloves, and aprons at all times. Additionally, ensure the canisters are always pointed up.**

Explain to students that they are going to determine how best to fire their film canister cannon.

- The film canister represents a cannon, the canister's cap represents a cannonball, the Alka Seltzer represents black powder, and dissolving it in water represents ignition.
- You can explain the basic idea that in this activity, Alka Seltzer will dissolve in water, produce a gas (CO_2) that will create pressure, and propel the cap off the canister.

Student Procedures

1. In your group, make a plan for how to fire your film canister cannons. Some things to consider are listed below.
    a. Water: the temperature of the water, how much goes in the canister
    b. Alka Seltzer: half tablet or whole tablet, crushed into powder
    c. General Steps: water added to Alka Seltzer or vice versa
2. Test your plan. Always wear goggles, gloves, and aprons, and ensure the canisters are pointed up.
3. After you have tested your plan, discuss how you can improve it and make a new plan. Some questions to consider are below.
    a. If your cannon did not fire, what can you do differently next test? Choose **one** thing to change.
    b. If your cannon did fire, how can you improve? (Faster, higher, etc.) Choose **one** thing to change.
4. Test your new plan. Always wear goggles, gloves, and aprons, and ensure the canisters are pointed up.
5. Repeat steps three and four as many times as needed.

Standard Procedure

1. Pour *warm* water into the canister until the canister is about half full.
2. Drop one whole tablet of Alka Seltzer into the water and *quickly* place the lid on the canister.
3. Step away and observe the reaction and "pop" of the cannon.

Scientific Explanation: Alka Seltzer contains sodium bicarbonate and citric acid, which react upon dissolution to form sodium citrate, water, and carbon dioxide. The carbon dioxide builds up pressure in the canister, causing the top to pop off.

Safety and Disposal

Goggles, gloves, and aprons should be worn at all times. For disposal of leftover materials, follow guidelines outlined by your campus and/or district.

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