Fire Prevention and Safety 6–8

Fire and Fire Prevention

LESSON PLAN 1

Fire Science

Combustion occurs when the three elements of the fire triangle—heat, fuel and oxygen—are present. Understanding this basic chemical reaction can help stop harmful fires before they start.

Key Terms and Concepts

ash
chemical reaction
combustion
Consumer Product Safety Commission
endothermic
exothermic
fire
flame retardant
flammable
flash point
fuel
heat
ignition temperature
O_2
oxidation
product
physical change
reactant
smoke

Purpose

To help the students understand the chemical nature of fire, combustion and oxidation

Objectives

The students will—

- Name the three elements of the fire triangle.
- Differentiate between physical changes and chemical changes to understand that fire, or combustion, is a chemical reaction.
- Use *Understanding the Chemistry of Fire* to explain the chemistry that occurs in a fireplace fire and show understanding of this concept by correctly describing several ways to extinguish the fire.
- Discuss and write rules for campfire safety based on their understanding of the chemistry of fire.
- Distinguish between molecular oxygen, O_2, and other molecules containing oxygen.
- Define the term "oxidation" with *Oxidation Chemistry and Cellular Respiration* and find examples of oxidation in nature other than fire. (Linking Across the Curriculum)
- Employ the information in *Oxidation Chemistry and Cellular Respiration* to explain the oxidation that takes place in cellular respiration and write a balanced chemical equation for the burning of glucose in living cells. (Linking Across the Curriculum)
- List products of fire that are dangerous, even in the absence of flames, and explain their danger.

American Red Cross

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- Conduct research on the Internet to discover which materials catch fire more easily than others; use *Firefighter Safety Equipment* to discuss ways firefighters protect themselves when fighting fires.
- Review the concept of flame-retardant treatment for household goods; visit the Consumer Product Safety Commission at *www.cpsc.gov* to learn how the government designates household products "flame resistant" and report their findings to the class. (Home Connection)

Activities

"The Chemistry of the Fire Triangle"

"Preventing Problems With the Products of Fire"

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Materials

- *Understanding the Chemistry of Fire*, 1 copy per student
- *Oxidation Chemistry and Cellular Respiration*, 1 copy per student (Linking Across the Curriculum)

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"The Chemistry of the Fire Triangle"

SET UP 5 minutes **CONDUCT** 50 minutes

Science: Chemistry and Physical Science; Language Arts: Reading

1. Review the concept of the fire triangle. Ask the students what is necessary for a fire. (Fuel, something that burns; oxygen, in the form of oxygen gas [O_2]; and heat sufficient to reach the ignition temperature of the fuel)

2. Ask the students to differentiate between physical changes and chemical changes and give examples of each.
   - Physical changes do not result in the formation of a new substance, for example, cutting paper, melting ice and freezing water.
   - Chemical changes cause the formation of new chemical combinations, for example, burning paper or wood, digesting food and photosynthesis.

   Which type of change happens in a fire? (Often both: The fuel is chemically combined with oxygen to form new substances, such as smoke and ashes. However, materials such as water may boil into steam, or metals may melt. Both are examples of physical change.)

3. Ask the students to consider fires in a fireplace. What are the fuels? (Wood, paper logs and gas.) Where do fires get oxygen? (They get oxygen from the O_2 in the air. About 21 percent of our atmosphere is O_2. The amount of O_2 supplied to the fire may be increased by using bellows or by blowing on the base of the fire.) What is the heat source? (Matches or lighters to start kindling having a low-ignition temperature or igniters that produce sparks to light gas.)

4. How can fires in the fireplace be extinguished? (Let the fire consume all the fuel; turn off the gas; remove the source of O_2 by smothering the fire with a nonflammable substance, such as sand or dirt; lower the temperature of the fuel and remove O_2 by dousing the fire with water.)

5. Distribute the glossary to help the students who may have trouble with the vocabulary listed on the activity sheet. Give students a short break to familiarize themselves with the words and their meanings.

6. Distribute *Understanding the Chemistry of Fire* and have the students complete the questions.

Answers to *Understanding the Chemistry of Fire*

1. Answers will vary, but may include the following facts:
   - Fire, or combustion, occurs when heat, fuel and oxygen (O_2) combine in a chemical reaction.
   - Since oxygen is present in the air, the campfire will continue to burn as long as fuel is added.

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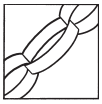
- Fire is a process of rapid oxidation, an exothermic reaction, because heat is always released. An endothermic reaction absorbs heat.
- To start a campfire, use flammable items or fuel with a low ignition temperature.
- When a log burns, it produces heat and light, as well as carbon dioxide, water and ash.
- Heat energy is released as the log burns. This means that the products of combustion contain less energy than the reactants.

2. The fire is safe because flammable objects are not near it. The fire is contained in a pit surrounded by stones and adults are supervising. Children are well back from the flames. A bucket of water is close by in case there is a problem. The amount of oxygen reaching the fire depends on the wind. If the wind picks up, the flames could blow out of control.
3. The wind could increase; materials with a low-ignition temperature could be brought near the fire; risk-taking behavior by the adults or children could result in a fire that is out of control. To extinguish the fire, remove the oxygen by smothering the flames with the dirt that surrounds the pit, or douse the flames with water to deprive the fire of heat and oxygen.


Wrap-Up

Have the students discuss and write rules for campfire safety based on their understanding of the chemistry of fire.



Linking Across the Curriculum

Science: Biology and Chemistry

For more advanced students: Explain to the students that fire is a rapid chemical change that occurs when a fuel in the presence of O_2 is brought to its ignition temperature. In chemistry, this type of reaction is called an oxidation reaction—oxygen is added. Many different oxidation reactions occur in nature which are not combustion, such as the rusting of iron and cellular respiration. Distribute *Oxidation Chemistry and Cellular Respiration* and have the students complete the sheet.

Answers to *Oxidation Chemistry and Cellular Respiration*

1. CH_4 replaces fuel; O_2 replaces oxygen; and a spark replaces heat.
2. Carbon, hydrogen and oxygen with possible traces of other elements
3. They burn organic materials, such as carbohydrates, fats and proteins found in the food they eat.

   To support the combustion of food.
4. $(C_6H_{12}O_6 + 6O_2$ + enzymes ➔ $6CO_2 + 6H_2O$ + heat energy

Note: Enzymes replace the spark needed to ignite the methane and the heat liberated is used for life processes.

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LESSON PLAN 1
Fire Science

Materials

Firefighter Safety Equipment, 1 copy per student

"Preventing Problems With the Products of Fire"

SET UP 15 minutes **CONDUCT** 50 minutes plus implementation

Science: Chemistry and Technology; Language Arts: Communication

TEACHING NOTE In this activity, it is best to invite a firefighter to participate. If it is not possible to have a firefighter visit, complete the activity by having the students share their ideas from the activity sheet.

1. Even when there are no flames, how can the products of fire be dangerous? (Smoke can impair breathing, and the particles contained in the smoke may be toxic. Ash can insulate embers and these hot embers can reignite an extinguished fire. The heat from smoldering fires can ignite fuel having a low-ignition temperature with which it comes in contact. Heat also causes the death of cells in exposed organisms. When skin cells are damaged, the organism is prone to infection.)

2. Explain to the students that the Consumer Product Safety Commission has set guidelines for the flammability of items such as clothing, tents, furniture and other household products. Flame-retardant chemicals are applied to household products to increase the ignition temperature, thereby decreasing the risk of fire.

3. Remind the students that firefighters expose themselves to the dangers of the products of fire when they enter burning or burned buildings. Ask: How does a firefighter protect himself or herself from heat, smoke, falling materials and the other results of residential fires? (Answers may include—helmet, face covering, breathing apparatus, flame- or heat-resistant clothing, boots and gloves.)

4. Arrange for a firefighter to visit your classroom and demonstrate his or her safety equipment. Before the visit, distribute and have the students complete *Firefighter Safety Equipment*.

Wrap-Up

During the visit, students should correct and expand the information on their activity sheets while the firefighter discusses safety equipment. Encourage the students to question the firefighter about how each piece of equipment reduces the risk of injury.

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Home Connection

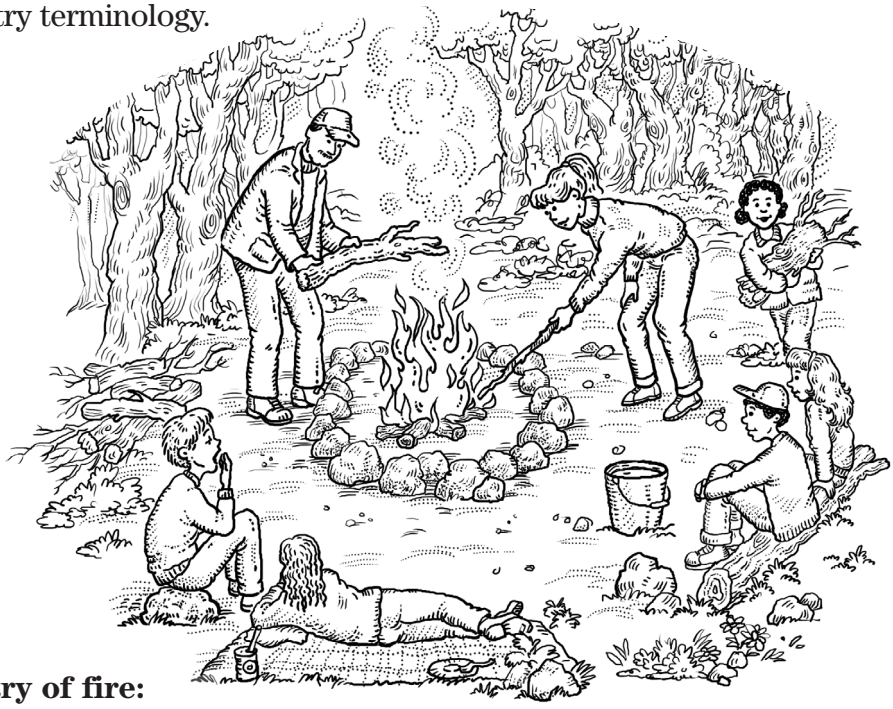
Review with the students the concept of flame-retardant treatments for household goods, comparing it to firefighters' turnout gear, which is resistant to flames. Direct the students to the Web site of the Consumer Product Safety Commission at *www.cpsc.gov* to learn how the government confers the designation of "flame resistant" on household products. Encourage some or all of the students to report their findings to the class depending on the amount of time you have.

Understanding the Chemistry of Fire

Name _____

Directions: Look at the picture below. Identify the terms listed to describe what is happening. Concentrate on the chemistry of the fire. Then answer the analysis questions using appropriate chemistry terminology.

combustion
oxidation
flammable
chemical reaction
products
reactants
fuel
heat
O_2
exothermic
endothermic
fire
ignition temperature



1. Describe the chemistry of fire:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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Understanding the Chemistry of Fire

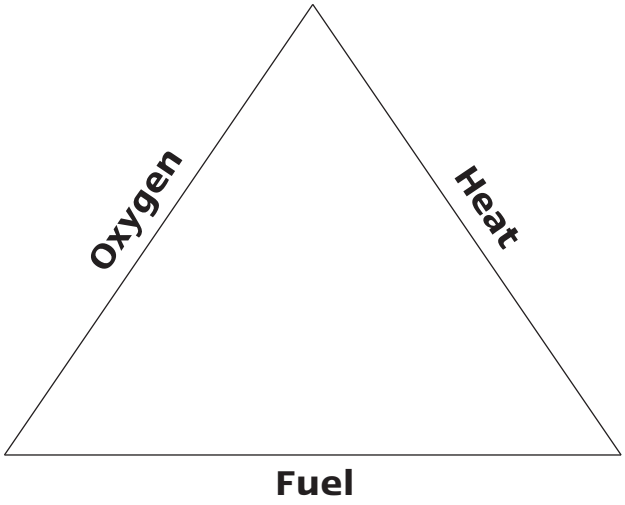
Analysis Questions

2. Is the fire shown in the drawing a safe fire? Why or why not? Which parts of fire chemistry are well controlled? Which parts are not controlled?

3. Explain one way this fire could get out of control and describe the chemistry involved. How could you put it out?

Oxidation Chemistry and Cellular Respiration

Name _____



REACTANTS				PRODUCTS				
CH_4	+	$2O_2$	→	$2H_2O$	+	CO_2	+	heat
methane		oxygen	spark	water		carbon dioxide		exothermic

Methane, a simple molecule composed of hydrogen and carbon (the simplest hydrocarbon), is a gas at room temperature. Methane burns readily in the presence of oxygen gas (O_2) and a heat source. In fact, if the amount of methane gas is adequate, a small spark can ignite the gas. Methane is one component of natural gas, a common fuel used for heating homes and cooking.

The chemical equation above shows the reaction that occurs when methane gas is burned. The **reactants** (methane and oxygen) are shown on the left side of the arrow. The **products** are shown to the right of the arrow. Burning methane gas also produces heat, which is an exo (out) thermic (heat) reaction. Please note that the number and kinds of each element in the products is the same for each element in the reactants; therefore, the equation is balanced. In word form the equation would read as follows:

> "In the presence of a heat source, such as a spark, 1 molecule of methane combines with 2 molecules of oxygen gas to form 2 molecules of water and 1 molecule of carbon dioxide, plus heat."

Oxidation Chemistry and Cellular Respiration

Directions:

1. In the space below draw another fire triangle. Label the sides with the correct elements from the chemical equation of methane combustion.

2. Can you think of other fuels that burn readily? Of what elements are these fuels composed?

_____

_____

_____

3. How do humans get the energy to carry out life processes? Why do humans need oxygen gas (O_2) to survive?

_____

_____

_____

4. Glucose — a sugar ($C_6H_{12}O_6$) — is a universal fuel for living organisms. Through metabolism, organisms, including humans, convert food to glucose that can be burned in the cells through a series of controlled steps. The products of these reactions are CO_2 and H_2O. Write a balanced chemical equation for the burning of glucose in living cells.

_____

Firefighter Safety Equipment

Name _____

Directions: Firefighters must protect themselves from fire and the products of fire. Examine the picture below and decide how each piece of equipment helps protect the firefighter. Detail your ideas in the table below.

Equipment	How It Protects	What Risk It Reduces

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