

# CHAPTER 4

## Arson and Fire Investigation

### HAPPY LAND FIRE



Figure 4-1. Happy Land social club after the fire.

Julio Gonzalez and Lydia Feliciano had dated off and on for six years. On March 25, 1990, Feliciano wanted to end the relationship. They argued at her workplace, a club in the Bronx called Happy Land. When Gonzales grabbed Feliciano's arm, the club's bouncers asked Gonzalez to leave. As he was being removed from the club, he shouted, "I'll be back, and I'll shut this place down!"

As Gonzalez walked away, he found an empty gasoline can. He filled it at a nearby gas station. The entrance to the club was a hallway that led to a staircase. The bar, the DJ, and most of the customers were at the top of those stairs. Gonzalez poured the gasoline along the hallway and on the steps. He used two matches to light the gasoline as he walked away. The gas ignited immediately, but the fire was initially contained to the hallway. Feliciano and a club customer noticed almost immediately and escaped. Most of the people in the club were upstairs listening to music. The DJ noticed the fire and announced it to the crowd. He then dived down the stairs and got out of the building.

When the DJ opened the door to get out, the rush of air provided more oxygen for the fire and pushed the fire up the stairs. A fire caused by gasoline on a wooden staircase produces thick black smoke. There were no windows or other ventilation upstairs. One of the gases in the smoke was

carbon monoxide. Carbon monoxide is easily absorbed by blood cells. Victims die quickly. The DJ was the last person to escape. In less than 10 minutes, 87 people were dead.

Later that morning, Feliciano went to the police station to tell her story. She told them about her argument with Gonzalez and about his threat. The police were suspicious and went to talk to Gonzalez. The home smelled of gasoline. Gonzalez put on his gasoline-soaked shoes before leaving with the officers. Almost as soon as Gonzalez was read his Miranda rights, he confessed. He stated he started the fire as revenge against his ex-girlfriend who would not take him back. Later that day he was arraigned on 87 counts of murder. On August 19, 1991, he was convicted of arson and one of the largest mass murders in United States history.



Figure 4-2. The arrest of Julio Gonzalez.

## OBJECTIVES

By the end of this chapter, you will be able to:

- 4.1 Define combustion reactions.
- 4.2 Discuss the four factors that are required to ignite and maintain a fire.
- 4.3 Explain the conditions in which fuels will burn.
- 4.4 Examine reasons why arson is difficult to detect.
- 4.5 Identify the four categories of fire.
- 4.6 Evaluate the significance of burn patterns discovered at an arson investigation.
- 4.7 Discuss the proper methods for detecting, collecting, preserving, and analyzing arson evidence.
- 4.8 Describe the psychological profile of an arsonist.
- 4.9 Examine the various motives for arson.



## VOCABULARY

- accelerant** - in fire investigation, any material used to start or sustain a fire; the most common are combustible liquids
- arson** - the intentional and illegal burning of property
- combustion reaction** - oxidation reaction that involves oxygen and that releases heat and light
- exothermic reaction** - chemical reaction that releases heat
- heat of combustion** - excess heat that is given off in a combustion reaction
- hydrocarbon** - any compound consisting only of hydrogen and carbon
- oxidation reaction** - the complete or partial loss of electrons or gain of oxygen
- pyrolysis** - decomposition of organic matter by heat in the absence of oxygen
- substrate control** - a similar, but uncontaminated, sample; used for making comparisons

## INTRODUCTION

Fire has always fascinated people. Greek philosophers believed fire was one of the four basic elements—earth, wind, water, and fire. They thought that everything was made of these four elements. Now we know that fire is a chemical reaction that produces heat, light, and gas.

### Obj. 4.1, 4.2, 4.3 CHEMISTRY OF FIRE

Fire is a rapid oxidation reaction that involves a combustible material. Combustible material is anything that will burn. For a long time, chemists thought that oxidation was the combination of any element with oxygen to form a new substance. For example, carbon (C) and oxygen gas (O<sub>2</sub>) react to form carbon dioxide (CO<sub>2</sub>).



When oxygen reacts with another element, that element's electrons shift toward oxygen. This means that oxygen gains an electron while the other element loses an electron. This shift of electrons is not always complete. In other words, sometimes the elements share the electron. Scientists have broadened the modern definition of oxidation to include any reaction in which electrons move from one substance to another. Therefore, some oxidation reactions do not involve oxygen. An **oxidation reaction** is the complete or partial loss of electrons or the gain of oxygen. For example, when sodium (Na) reacts with chlorine (Cl<sub>2</sub>) to form sodium chloride (NaCl), or table salt, sodium loses an electron. In this reaction, sodium is oxidized.



## COMBUSTION

Some oxidation reactions are called combustion reactions. **Combustion reactions** are oxidation reactions that involve oxygen and that produce flames (see Figure 4-3). Combustion reactions release energy in the form of heat and light. The excess heat energy is referred to as the **heat of combustion**. Chemical reactions that release heat are called **exothermic reactions**.

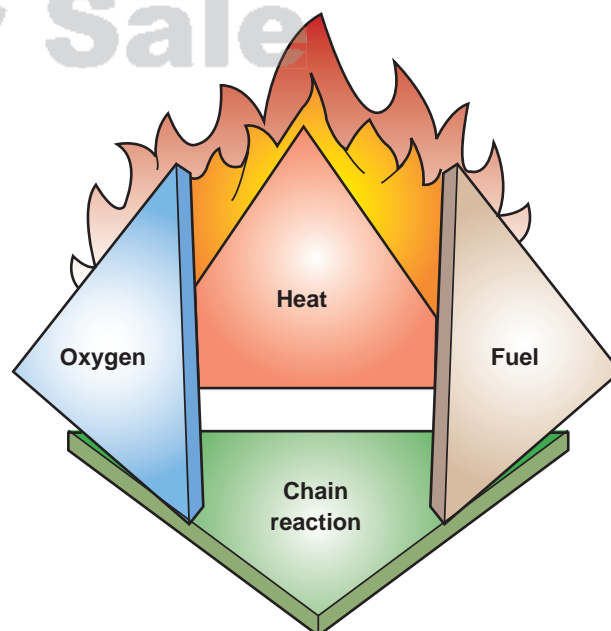


**Figure 4-3.** Flames are the light released during combustion.

## THE FIRE TETRAHEDRON

Four ingredients (see Figure 4-4) are needed to start a fire and to keep it burning:

1. *Oxygen*. Because oxygen is a major gas in the air, it is usually available. Oxygen is an important ingredient in any combustion reaction.
2. *Fuel*. The fuel is the material that is burning. If present, the accelerant burns first. In a fire investigation, an **accelerant** is any material used to start or maintain a fire. Soon, other nearby materials, such as wood or paper, ignite and become fuel for the continuation of the fire.
3. *Heat*. When a heat source is present, the temperature of a substance rises. Different fuels react with oxygen at different temperatures. The temperature at which a fuel will react with oxygen, or burn, is called the *ignition temperature*. At or above the ignition temperature, the fuel will continue to burn even after the heat source is removed.
4. *Chain reaction*. The fire itself usually releases enough heat to keep the fire burning. The fire will continue to burn until all of the oxygen or the fuel is used or removed.



**Figure 4-4.** The fire tetrahedron is a model used to describe how a fire starts and keeps burning.

## FLASH POINT AND IGNITION TEMPERATURE

Most accelerants are hydrocarbons. **Hydrocarbons** are compounds that are made of only hydrogen and carbon atoms. Gasoline, kerosene, and lighter fluid are hydrocarbons that can be used as accelerants. To react with oxygen, most accelerants must be in the gas state.

In a gas, the molecules are much further apart than in a liquid. Additionally, molecular bonding is weaker in the gas state. For example, liquid gasoline will not burn, but gasoline vapors will. When a liquid changes to the gas state, the process is called *vaporization*. For a liquid to burn, there must first be enough heat to vaporize the liquid. The lowest temperature at which this happens is called the *flash point*. At the flash point, the accelerant will continue to burn only as long as there is a heat source. The flash point of gasoline is  $-46^{\circ}\text{C}$ . The flash point of gasoline, therefore, is  $46^{\circ}\text{C}$  less than the freezing point of water. Flash points and ignition temperatures of some commonly used accelerants are shown in Figure 4-5.



Accelerant	Flash Point ( $^{\circ}\text{C}$ )	Ignition Temperature $^{\circ}\text{C}$
Acetone	-20	465
Gasoline	-46	257
Kerosene	52-96	257
Mineral spirits	40-43	245
Turpentine	32-46	253

SOURCE: IAAI. (1999). A POCKET GUIDE TO ACCELERANT EVIDENCE COLLECTION (2ND ED.). MASSACHUSETTS CHAPTER.

**Figure 4-5.** The flash points and ignition temperatures of several commonly used accelerants.

At any temperature above the flash point, some of the liquid is becoming a vapor. These vapors can ignite. Gasoline's ignition temperature is 257°C. Once it reaches that temperature, gasoline will burn and continue burning.

## PYROLYSIS



Figure 4-6. Wood fire.

Solid fuels, such as wood, are not flammable. However, vapors given off from the resins in the wood are flammable and will burn. As the wood itself decomposes in the fire, additional flammable vapors are released (see Figure 4-6). The process of decomposition caused by heat in the absence of oxygen is called **pyrolysis**. Charcoal, another common solid fuel, will not burn unless a liquid fuel is applied. The liquid fuel, often called *charcoal starter* or *lighter fluid*, is poured onto the charcoal. As the liquid vaporizes, it becomes flammable. Lighting it with a match causes a flame, and the heat from the flame decomposes the charcoal (see Figure 4-7). As the charcoal undergoes pyrolysis, more flammable vapors are released to sustain the fire.

### Digging Deeper

with Forensic Science e-Collection

Certain behaviors and circumstances are considered “red flags” for arson investigators. For example, if the well-insured property of a person in debt burns, investigators might become suspicious. Sometimes, these red flags help investigators solve a crime. Sometimes, however, these red flags have innocent explanations. Cases involving fire are not always what they seem. Using the Gale Forensic Science eCollection at [www.cengage.com/school/forensicscienceadv](http://www.cengage.com/school/forensicscienceadv), read about how some investigators use these red flags. Then answer the following questions: (1) What red flags were described in this case? (2) How are burn patterns important in determining the cause of a fire? (3) Where was the fire's point of origin, and what did that indicate? (4) How are burn patterns and red flags different?



## DIFFICULTIES IN ARSON DETECTION

Obj. 4.4

According to the National Fire Protection Association, fires caused more than \$15 billion worth of property damage and killed more than 3,000 people in the United States in 2008. Accidents, such as faulty wiring or carelessness, cause many of the fires. For example, if someone falls asleep with a lighted cigarette or throws a lighted cigarette on dry grass, a fire can start. Unattended candles can also cause fires. Still other fires start when a fuel is stored in a warm place where there is little airflow. For example, as organic material decomposes, it releases heat. Decomposition takes place at the bottom of haystacks and in compost piles. If the temperature around the organic material gets high enough, the material might burn. Fires have also started when vapors from oily rags stored in a hot garage or storage building have been ignited by very high temperatures.



Figure 4-7. Charcoal fire.

Unfortunately, some fires are started on purpose. It is a crime to intentionally start a fire that damages property. This crime is called **arson**. The person who commits this crime is called an *arsonist*.

Arson is a very difficult crime to prove. The crime is usually carefully planned. The arsonist has usually left the scene well before anyone else notices the fire. The fire often destroys evidence from the crime, and what evidence is left is often destroyed as firefighters extinguish the fire. Therefore, investigators are left with little physical evidence to analyze. Combustible liquids are often used as accelerants in an arson fire. Any remaining traces of chemical accelerants usually evaporate very quickly. Detection of accelerants will be discussed later in this chapter.



Arsonists often escape punishment. Only 16 percent of arson offenses lead to arrest, and only 2 percent of those arrested are convicted.

## FUNCTION OF A FIRE INVESTIGATOR



Obj. 4.5

Firefighters are the first people to respond to a fire. Their priority has to be putting out the fire and saving any victims. As soon as a fire is out, the investigation begins quickly. Otherwise, evidence will be lost. At first, the main focus of the fire investigation is finding the fire's point of origin. In other words, investigators search for the point where the fire started. Once investigators find the point of origin, they examine the area for possible causes of the fire. Investigators look for accidental causes as well as evidence of arson. Investigators use four broad categories to classify fires (see Figure 4-8).



In 2006, 10 firefighters died and 7,200 others were injured while responding to intentional fires.

Category	Description
Natural	A fire caused by acts of nature: a lightning strike or intense sunlight
Accidental	A fire that was unintentional and explainable; causes may include faulty wiring, malfunctioning appliances, or human carelessness
Undetermined	The cause of the fire is unknown and cannot be identified
Deliberate	A fire that was intentionally set (Not all deliberate fires are arson. For example, a campfire might spread out of control.)

Figure 4-8. Fire categories.

If investigators determine that the fire was not natural, they will try to find the person who started the fire. Investigators might prosecute someone who starts a fire, even if that person started the fire by accident.

## DETERMINING CAUSE



Obj. 4.6

The point of origin can provide clues about the cause of a fire. The point of origin will be marked by a burn pattern. There often is a V-shaped burn near the point of origin. This shape is caused as the fire travels up from the point of origin. The V-shaped burn pattern is usually present in cases of natural or accidental fires. However, in cases of arson, other

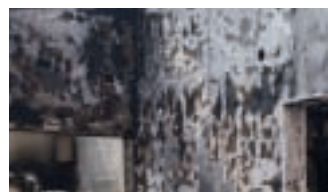
## Digging Deeper

with Forensic Science e-Collection

At the scene of a fire, investigators work hard to gather facts that will help them determine the cause of the fire. They might need to examine and analyze debris found at the scene. Additionally, investigators interview any witnesses to the fire. Eventually, fire investigators develop a report of their findings. Go to the Gale Forensic Science eCollection at [www.cengage.com/school/forensicscienceadv](http://www.cengage.com/school/forensicscienceadv) to learn more about fire investigation. Use information from the article to write a brief essay describing fire investigation. Include answers to the following questions in your essay: (1) How are burn patterns important in determining the cause of a fire? (2) Explain the four causes of fire. (3) How can a fire be deliberate but not arson? (4) What guiding questions help investigators determine the origin of a fire?



**Figure 4-9.** Alligatoring.



**Figure 4-10.** Concrete spalling.

burn patterns may be found. Instead of a V-shaped burn, the point of origin might be surrounded by a burn pattern resembling the scales of an alligator. This burn pattern is called *alligatoring* (see Figure 4-9). The point of origin might also be surrounded by melted materials or concrete spalling. *Concrete spalling* is the breaking away of layers of concrete (see Figure 4-10). Both alligatoring and spalling are caused by intense heat. Because accelerants often cause fires that burn at higher temperatures than natural and accidental fires, these burn patterns are sometimes an indication of arson. Figure 4-11 on the next page lists several burn patterns and describes the clues they give investigators.

The burn pattern found near the point of origin might suggest that a fire was set on purpose. For example, some fires have more than one point of origin. It is possible for an accidental fire to have more than one point of origin, but it is not likely. Also, the way a fire appears to have spread can also suggest that the fire was set on purpose. More burning on the floor than on the ceiling and more burning on the underside of furniture indicate that an accelerant might have been used. Burn patterns that look like puddles are an indication that an accelerant was poured. These are called *pools* or *plants*. *Streamers*, which often connect pools, are trails of accelerants used to spread the fire. Streamers and other unnatural burn patterns also indicate the use of accelerants.

Obj. 4.7

## COLLECTING THE EVIDENCE

Because accelerants often evaporate quickly, investigators must collect evidence from a fire as soon as possible. Investigators do not need to wait for a search warrant. The United States Supreme Court has upheld that a search warrant is unnecessary when evidence is likely to be lost. However, investigators need to get a search warrant for any later searches.

During the initial search, investigators often collect 3–4 L of ash and debris from the point of origin (see Figure 4-12 on the next page). They



Pattern	Description	Indication
Classic V	Burn pattern narrower at bottom and spreads outward as it rises	Ordinary burn pattern, no accelerant used
Inverted cone	Burn pattern is wider along the floor and narrower as it burns upward	May be caused by an accident or by accelerant poured along the floor
Alligatoring	Burn pattern resembling the scales of an alligator	Possible use of an accelerant, but not absolute
Spalling	The breaking away of layers of concrete due to exposure to high temperatures	Possible use of an accelerant, but not absolute
Streamers	Burn pattern that shows a trail from one area to another	Accelerant used to spread the fire from one area to another
Arc damage	Spark caused by a release of electricity	Electrical fire; may also be a result of a fire that has burned through wire insulation
Pool or plant	A burn pattern in a puddle configuration	Poured accelerants accumulated in a pool at the lowest point

**Figure 4-11.** Burn patterns.

also collect anything that could have traces of accelerant. Accelerants tend to flow down. This means that there might be traces of unburned accelerant in cracks in the floor or in upholstery. Investigators use portable vapor detectors, or sniffers, to search for debris that might hold traces of an accelerant. The sniffers detect molecules and particles in the air. Data from the sniffer can help investigators identify the area where accelerants may have been poured. Some investigators may even use arson dogs (see Figure 4-13 on page 112). Dogs have a very good sense of smell and can cover a wide area quickly. The dogs are trained to alert their handler when certain scents are present. These abilities make dogs very useful in detecting quantities of accelerant too small for the mechanical sniffers.

**Did You Know?**

The bedroom is the most common point of origin for intentionally set fires in the home. In public places, such as schools or offices, bathrooms are the most common point of origin.

## COLLECTING THE CONTROL

Investigators often take several evidence samples from the scene. Each sample is packaged in its own container. Investigators also take a debris sample that has not been contaminated by the accelerant. This uncontaminated sample is called a **substrate control**. The substrate control must be packaged separately. The substrate control is compared to the other samples. These comparisons might help investigators prove that an accelerant was used. The burned substrate control gives information about products formed during the burning process. These products will also be



**Figure 4-12.** Collecting fire debris.



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**Figure 4-13.** An arson dog helps an investigator search for traces of accelerant.

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**Figure 4-14.** Clean, unused paint cans are often used for collecting fire debris.

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**Figure 4-15.** The charred electrical outlet and the surrounding burn pattern indicate an electrical fire.

found in the contaminated sample. However, any additional chemicals found on the contaminated sample can help investigators determine what kind of accelerant was used to start the fire. For example, some carpeting might be covered in flammable residues from carpet-cleaning products. Linoleum flooring breaks down into materials that might be mistaken for accelerants. If the suspect hydrocarbon is found in the fire debris but not in the substrate control sample, it is more likely to be the trace of an accelerant. If, on the other hand, the suspect hydrocarbon is found in both samples, the hydrocarbon was probably not used as an accelerant.

## PACKAGING THE DEBRIS

Fire debris must be packaged in an airtight container. Otherwise, vapor from accelerants might be lost. Investigators often use new, clean paint cans with airtight lids (see Figure 4-14) for the collection. Investigators do not fill the cans completely. The sample might release vapors. Therefore, investigators leave a few inches of space, called *headspace*, below the lid.

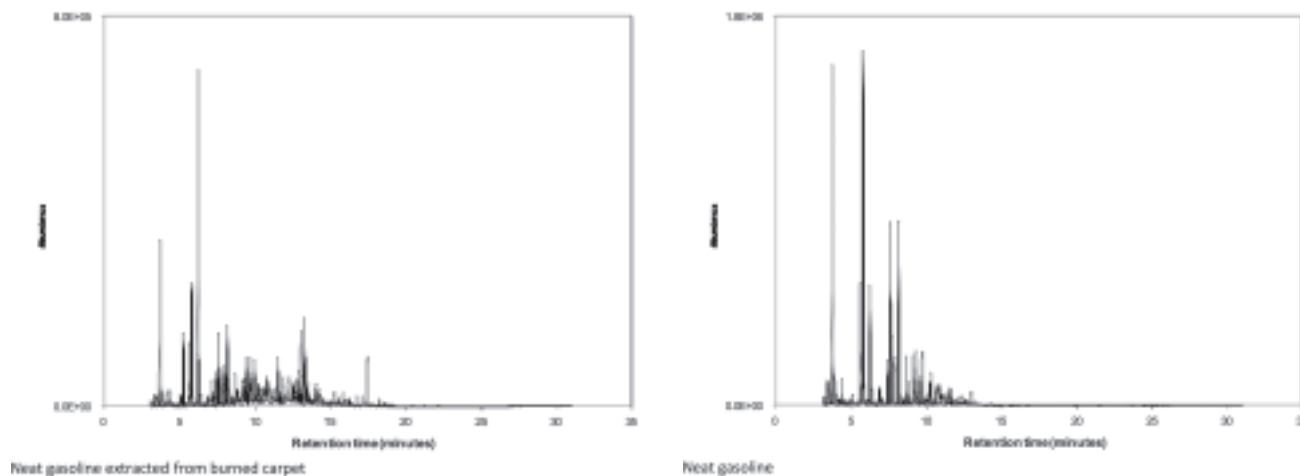
## FINDING THE IGNITER

Once fire investigators determine that an accelerant was used to start a fire, they need to find out what was used to light the accelerant. Matches are very common, but they usually are destroyed in the fire. Cigarette lighters are usually carried away from the scene. Sometimes, the arsonist uses things that leave evidence behind. For example, a Molotov cocktail will leave glass fragments behind. A *Molotov cocktail* is a homemade firebomb made with a glass bottle, fuel, and a wick. An accidental fire might be caused when electrical wiring sparks—causing an arc. This arc will cause a predictable pattern (see Figure 4-15). Electrical sparking devices, devices used to produce a spark, will also leave evidence behind. Faulty wiring might have produced the spark in an accidental fire. An arsonist might use a spark plug, fuse, or other device to make a spark to ignite the fire. Some part of this device is likely to be found during an investigation. Discovering the igniter, coupled with the accelerant used to start the fire, gives investigators information about the arsonist. For example, the arsonist's method of operation, or the methods the arsonist used to start the fire or to leave the scene, can sometimes be used to make a criminal profile. The *criminal profile* is a list of likely characteristics, such as age, gender, or motives. The profile helps the investigators narrow the list of suspects. By narrowing the list of suspects, investigators might be able to learn the identity of the arsonist. If an arsonist is responsible for more than one fire, the method of operation might help investigators connect the arsonist to all of the fires.



Fire investigators will send all of the evidence to the lab for analysis. At the lab, forensic scientists will try to determine exactly what accelerant was used to start the fire. One method used to analyze accelerant residue from the collected debris is called the *direct headspace extraction procedure*. Remember that headspace is the space between the collected fire debris and the top of the container. When the container is heated, the vapors in the debris will collect in the headspace. The vapors are removed directly from the headspace with a syringe. The collected vapor is then analyzed using gas chromatography (GC). GC separates the accelerant vapors into individual components. Each component is recorded as a separate peak on a chromatogram (see Figure 4-16). Remember that in GC, a gaseous mixture is passed through the chromatograph. When a liquid sample is injected into the GC, the liquids vaporize and are carried through the system as a gas. Different components of the original mixture will take different amounts of time to reach the recording device, or the detector. First, forensic scientists compare the chromatograms of the fire debris and the substrate control. This comparison shows whether an additional chemical is found in the fire debris. This additional chemical would produce additional peaks on the chromatogram. Then, forensic scientists compare the additional peaks on the chromatogram from the fire debris to chromatograms of known hydrocarbons, such as gasoline, kerosene, or lighter fluid. This comparison allows the scientists to identify the accelerant. For a more detailed review of chromatography, turn to Chapter 3.

In the direct headspace extraction procedure, the amount of vapor collected is limited by the size of the syringe. Therefore, low concentrations of accelerant may not be detected. For this reason, many crime labs now use a technique called *passive headspace extraction procedure* to obtain traces of residue from the debris for analysis.



**Figure 4-16.** The chromatogram on the left is the chromatogram from residues from a burned carpet. The chromatogram on the right is the chromatogram of gasoline. Notice that the two chromatograms share some peaks, indicating that there was gasoline on the carpet.



**Figure 4-17.** Passive headspace extraction procedure.

In the passive headspace extraction procedure (see Figure 4-17), a charcoal-coated strip is suspended in the headspace above the collected debris. The entire container, with the lid in place, is heated for four to 16 hours at 50–80°C. Any accelerant in the debris vaporizes and the charcoal absorbs the vapor. The charcoal strip is then removed from the container and washed with a small amount of organic solvent such as carbon disulfide. The solvent dissolves the accelerant but not the charcoal, thus removing the accelerant from the charcoal. The recovered accelerant is then analyzed using a gas chromatograph in the same manner as the direct headspace extraction procedure. The passive headspace extraction procedure is about 100 times more sensitive than the direct headspace extraction procedure. Lower concentrations of accelerant are more easily detected.

**Obj. 4.8**

## PSYCHOLOGY OF AN ARSONIST



Psychologists think that arsonists often start fires for the sense of power they feel from watching their “work.” The power gives the arsonist a physical and emotional “high” that is similar to a person’s reaction to illegal drugs. Although there is not a typical arsonist, profilers have determined a set of characteristics often exhibited by arson suspects. This list of characteristics includes the following:

- Less than 25 years old
- Father not in the home
- Domineering mother
- Academically challenged
- Emotionally and/or psychologically disabled
- Unmarried, possibly still living at home with parents
- Feelings of inadequacy and insecurity
- Fascination with fire
- Alcoholism
- Parental neglect or abuse



These are common characteristics that have been linked to arsonists after psychological analysis of the suspect. Arsonists typically exhibit several, but not all, of the characteristics. Additionally, some arsonists do not display any of these characteristics; and not all people with these characteristics are arsonists. This list of characteristics is just one tool investigators can use to solve arson cases.

Research shows that adult serial arsonists often displayed certain behaviors in childhood. Behavior such as aggression, cruelty to humans and animals, destruction of property, deceit, and theft can indicate a conduct disorder. If a child has a conduct disorder, he or she often violates the rights of other people. If a child who has a conduct disorder starts a fire, it is usually with the clear intent to harm others or to damage property. Typically, children with this conduct disorder are male and very impulsive. Parents should seek professional help if a child exhibits several of the following signs:

- At the age of three, the child begins playing with matches.
- The child behaves as a “daredevil,” especially when it comes to fire.
- The child makes his or her own mixtures to cause fires and explosions.
- The child is excited by fire.

### Did You Know?

There appears to be a growing link between arson and illegal drug activity. Preliminary results of a new study by the National Fire Protection Association suggest that between 20 and 25 percent of reported arson cases in major American cities are drug related.

## MOTIVES FOR ARSON



Obj. 4.9

People start fires for various reasons. Establishing motive is essential to the criminal investigation. The motives for arson tend to fall into six broad categories. Arsonists might start fires for financial gain, revenge, excitement, vanity, to conceal a crime, or as an act of vandalism.

### FINANCIAL GAIN

Some people start fires for financial gain, usually through insurance fraud. Most homeowners have insurance for their house and its contents. If a house or business is damaged in an accidental fire, the insurance company gives the owner money to replace the building and its contents. Sometimes, people deliberately burn the house to collect the insurance money (see Figure 4-18). Other people burn vehicles for similar reasons. Arsonists might also burn a competitor’s business. In this case, the arsonist might hope to get money by taking the competitor’s customers. For this reason, insurance companies instigate many arson investigations. Most insurance



**Figure 4-18.** Sometimes an arsonist hopes to receive insurance money after a fire.

## Digging Deeper

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Fires are very dangerous. They kill thousands of people each year. A person who starts a fire that kills someone may be convicted of murder. In some states, the arsonist faces the death penalty. Go to the Gale Forensic Science eCollection at [www.cengage.com/school/forensicscienceadv](http://www.cengage.com/school/forensicscienceadv) to read about controversy surrounding some arson convictions. Review and discuss the article with a partner. Together, write a position paper or present a debate for your class. Be sure to address the significant ethical issues in the cases. Discuss the role of the Innocence Project and whether the group should be allowed to review all arson cases. Finally, explain your opinions about the outcome in the Willingham case.



companies employee professional arson investigators who are trained to determine whether a fire was caused by arson.

## REVENGE

*Revenge arson*, also referred to as *spite arson*, is a fire started to destroy an organization or a person for the sake of a cause. For example, some animal rights groups have burned animal research facilities to protest the use of animals for research purposes. Fires started as a result of jealousy or prejudice also fall into this category.



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**Figure 4-19.** Some arsonists are excited by fire itself.

## EXCITEMENT

Some people think that setting fires is exciting. People who set these fires might be bored or seeking attention. These arsonists are particularly dangerous—they generally have no specific target and the fires are random. They will burn anything at any time, just for the excitement (see Figure 4-19).

## VANITY

Sometimes, the person who sets the fire is able to make himself or herself look like a hero. For example, the arsonist may pose as a passerby and report the fire. She or he might then get attention or even a reward for protecting the property or saving lives. People who create situations that make them appear to be brave suffer from hero syndrome. Basically, these arsonists are setting the fires out of vanity. They crave the positive attention they expect when they “save the day.”

## CRIME CONCEALMENT

Sometimes people start a fire to destroy evidence of another crime. This motive is called *crime concealment*. For example, a bank robber might steal a car to leave the bank. The robber might then burn the car to destroy evidence that might connect the robber to the car. A body burned inside a car or house to cover up a murder is also a form of crime concealment.

## VANDALISM

The last category of arson is *vandalism*. School fires and fires in trash cans or dumpsters (see Figure 4-20), wooded areas, and abandoned buildings are often acts of vandalism. People under the age of 18 commit most of these crimes. Vandalism fires may also be categorized as revenge or excitement arsons.



TFOXFOTO/SHUTTERSTOCK

**Figure 4-20.** A dumpster fire may be an example of vandalism.

## CHAPTER SUMMARY

- Fire is an oxidation reaction that involves a combustible material. Not all oxidation reactions produce fire.
- The fire tetrahedron represents the four requirements for sustained fire—oxygen, fuel, heat, and a chain reaction.
- Most fuels are hydrocarbons. They typically have very high ignition temperatures. The ignition temperature is the temperature at which a fuel will light and continue to burn even if the heat source is removed.
- The initial focus of a search at the scene of a fire is to find the fire's point of origin.
- The burn pattern helps investigators determine whether the fire was natural, accidental, or deliberate.
- Three to four liters of ash and debris are generally collected from the point of origin and any area suspected of having traces of accelerant. Each sample of debris is placed in a separate airtight container.
- For comparison purposes, investigators also collect a substrate control.
- The direct headspace extraction procedure and vapor concentration are two methods of collecting accelerant vapors for analysis.
- Gas chromatography is used to analyze the accelerant residue. The resulting chromatogram is compared to chromatograms of known hydrocarbons in order to determine what type of accelerant, if any, is present.
- Psychologists have determined a set of characteristics that arsonists tend to exhibit. This set of characteristics helps investigators focus their search.
- Arsonists set fires for many reasons. Most of the motives fit into six broad categories—financial gain, revenge, excitement, vanity, crime concealment, and vandalism.

## CASE STUDIES



### Berns Triplets (1988)

At 6:00 p.m., on September 21, 1988, the Berns triplets were asleep in their crib. They were 17 months old. Their father, Scott Berns, was asleep on the couch. He woke up when he noticed smoke filling the room. He immediately ran outside of the home and shattered the triplets' window.

The three girls were pulled from the burning house. Their mother, Patti Berns, died from smoke inhalation. The girls had third-degree burns, but they survived. Police suspected arson from the beginning. Suspicious burn patterns suggested that the fire had started near the couch where Scott Berns had been sleeping. Figure 4-21 shows the home after the fire was extinguished.

After almost two years, Berns was indicted. Berns abused prescription and illegal drugs. Witnesses said that he had shot at his wife's car earlier that day as she was leaving the home. However, it is very difficult to determine exactly what happened in cases of arson. The jury decided that there was

reasonable doubt in the case against Scott Berns. Three strangers had been seen near the home the day of the fire. It was possible that the strangers had started the fire. Scott Berns was acquitted.



**Figure 4-21.** The Berns' home after the fire.



**Think Critically** 1. What does it mean that the “jury decided that there was reasonable doubt”?

2. Why is it often very difficult to prove arson cases?

## John Orr (1984)

For several years, California was plagued by a series of arson fires. One of the fires resulted in the loss of 65 homes. A fire at a hardware store in Southern California killed four people. Investigators combed the areas and searched for clues; however, no clear pattern was found. Arson and fire investigations expert Marvin Casey noticed that the first fires were in Los Angeles. Each fire after that was further north. The pattern was moving toward Fresno, California. Casey also noted the odd coincidence that Fresno was the host city of an arson investigators convention. With this tenuous lead, Casey came up with 55 names of possible suspects. After several more years and another convention in Los Angeles, the suspect pool was finally narrowed down to just one individual—John Orr (see Figure 4-22). Orr was a respected arson investigator. People who knew him and worked with him were stunned by the accusation. Orr suffered from hero syndrome. He may also have been excited by the power he thought the fires gave him. Eventually, he was caught and convicted of four murders. He is serving a life sentence without the chance of parole. Arson investigators and criminal profilers think that Orr was one of the worst serial arsonists of the 20th century.



Figure 4-22. John Orr.

AP PHOTO/POOL, WALLY SKALLU



- Think Critically**
1. Describe *hero syndrome* and explain how it relates to this case.
  2. How did the arson investigator's attention to detail bring closure to this case?
  3. Do you think the fact that Orr was an expert arson investigator contributed to the sentencing recommendation? Explain.

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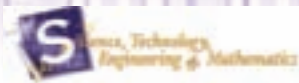
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# CAREERS IN FORENSICS



## Jack Shannon: Arson Dog Handler/Trainer



COURTESY OF JACK SHANNON

**Figure 4-23.** Jack Shannon, pictured here with one of his arson detection dogs.

Jack Shannon (see Figure 4-23) works for the Vigo County Sheriff's Department in Terre Haute, Indiana. He is a K-9 handler and owns a dog-training school. Shannon has always loved dogs and began training dogs when he was 10 years old. He has been training dogs for more than twenty years! As an adult, he has graduated from several dog-training schools, including police dog-training schools. Shannon says that being able to read a dog's body language is essential for K-9

officers. "You have to give the dog time to work and not interfere with the dog."

Not all dogs make good arson detection dogs. An arson detection dog needs to have a strong *prey drive*, a desire to chase and catch. A dog who enjoys a game of fetch could be a candidate for detection training. An arson detection dog should also have a strong *hunt drive*. A dog who hunts enthusiastically for a toy hidden in weeds might be a good candidate. Shannon adds, "Throwing the toy into the weeds forces the dog to use his nose and not his eyes." A good arson detection dog will also be very possessive of the toy and reluctant to give it up.

To train the dog, the toy is scented with the target odor—an accelerant, for example. The trainer then hides the toy. The dog is taught to hunt for that odor by hunting for the scented toy. Once the dog finds the odor, the dog sits and waits for the handler. Many arson detection dogs are also trained to find explosives. Therefore, the dogs are trained not to scratch at the dirt or the debris. Scratching could detonate an explosive. Shannon adds, "A detection dog is really only searching for his toy. When he finds the target odor, he knows his toy will appear and playtime begins."



### Learn More About It

To learn more about arson dog training, go to [www.cengage.com/school/forensicscienceadv](http://www.cengage.com/school/forensicscienceadv).

# CHAPTER 4 REVIEW

## Matching

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- |   |                         |
|---|-------------------------|
| 1. heat produced when a substance is burned in oxygen <i>Obj. 4.1</i>   | a. pyrolysis            |
| 2. any compound consisting only of carbon and hydrogen <i>Obj. 4.3</i>  | b. combustion reaction  |
| 3. minimum temperature at which an accelerant will burn and continue to burn <i>Obj. 4.2</i>                    | c. hydrocarbon          |
| 4. any material used to start or maintain a fire <i>Obj. 4.7</i>  | d. heat of combustion   |
| 5. chemical reaction that involves a loss of electrons or a gain of oxygen <i>Obj. 4.1</i>                      | e. flash point          |
| 6. the intentional and illegal burning of property <i>Obj. 4.4</i>  | f. accelerant           |
| 7. decomposition of organic matter by heat <i>Obj. 4.3</i>  | g. arson                |
| 8. combination of oxygen with another substance, producing heat and light in the form of flames <i>Obj. 4.1</i> | h. oxidation reaction   |
| 9. minimum temperature at which liquid fuel will produce vapor <i>Obj. 4.2</i>                                  | i. exothermic reaction  |
| 10. chemical reaction that releases heat <i>Obj. 4.1</i>  | j. ignition temperature |

## Multiple Choice

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11. Which of the following is the most sensitive and reliable procedure for extracting combustible residues? *Obj. 4.7*
- high-performance liquid chromatography
  - direct headspace extraction procedure
  - gas chromatography
  - passive headspace extraction procedure
12. The identity of an accelerant is determined by the pattern of its \_\_\_\_\_ . *Obj. 4.7*
- burn
  - debris
  - atomic spectrogram
  - gas chromatogram
13. \_\_\_\_\_ are trails of accelerant use to carry a fire from one location to another. *Obj. 4.6*
- Streamers
  - Vapors
  - Molotov cocktails
  - Burn patterns

14. Most fuels cannot burn in the liquid state. What physical change must take place before a liquid fuel can burn? *Obj. 4.3*
- a. pyrolysis
  - b. solidification
  - c. vaporization
  - d. decomposition
15. After the fire has been extinguished, the initial focus of the investigation at a fire scene is \_\_\_\_\_. *Obj. 4.6*
- a. determining whether the fire is arson
  - b. identifying the accelerant
  - c. finding the igniter
  - d. locating the point of origin
16. Which of the following burn patterns most strongly suggests that a fire was either accidental or natural? *Obj. 4.5, 4.6*
- a. a "V" burn pattern
  - b. concrete spalling
  - c. alligating of wood
  - d. streamers
17. Which of the following is a true statement about arson investigation? *Obj. 4.3, 4.5, 4.7*
- a. Fire investigators need to obtain a search warrant before collecting fire debris.
  - b. All deliberate fires are considered arson.
  - c. Wood does not burn in a fire.
  - d. In the direct headspace extraction procedure, a charcoal strip is inserted into the evidence container with the fire debris.

## Short Answer

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18. What are some indications of accelerant use in a fire? *Obj. 4.5*

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19. Why must all materials suspected of containing hydrocarbon residues be packaged in airtight containers? *Obj. 4.7*

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20. Explain the terms *oxidation reaction* and *combustion reaction*. How are these terms related? *Obj. 4.1*

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21. Why is it necessary to leave headspace in a container of fire debris? *Obj. 4.6*

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22. Describe the four categories of fires. *Obj. 4.5*

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23. Why are arson crimes difficult to detect and prove? *Obj. 4.4*

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24. The motives for arson fires usually fall into six broad categories. Describe each of the six categories. *Obj. 4.9*

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25. Describe the psychological profile of an arsonist and how investigators use this information. *Obj. 4.8*

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**Think Critically** 26. Does the absence of chemical residues rule out the possibility of arson? Why or why not? *Obj. 4.5*

27. Online or at the library, find information about three different arson cases. Find information about one case that resulted in a conviction, one that resulted in an acquittal, and one that involved a conviction that was later overturned. Write an essay that discusses the significant differences in the three cases. Explain the value of arson evidence in court. *Obj. 4.7*

28. Research the differences in training for an arson investigator and a fire investigator. Examine the importance of arson evidence from each perspective. *Obj. 4.7*

## The Wynndom Warehouse Fire

By: **Yessenia Ramos**

*East Ridge High School  
Clermont, Florida*

Amery Duke noticed the fire as she was driving past and hysterically called 911. When firefighters arrived, her red dress was blackened from soot and was torn in several places from trying to get into the building. After firefighters extinguished the fire, investigators searched the area to find the point of origin. A charred body was found on the floor of the burned out warehouse office (see Figure 4-24).

Within minutes, the fire was determined to be arson. There were streamers from the entrance of the building to the office. Just inside the entrance, investigators found wood exhibiting the alligator pattern of intense heat—the point of origin of the fire. The next step included talking to possible witnesses.

Dental records were used to identify the body as Sandra Anderson. From the carbon monoxide in the lungs, the medical examiner determined that the cause of death was smoke inhalation, not the blow to the head that apparently rendered her unconscious. Upon further examination, a small red button was found clutched in her right hand.



**Figure 4-24.** Warehouse fire.

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The following statements were obtained from witnesses:

- Sandra had been upset earlier in the day, but tried to cover her emotions. Several people overheard Sandra and Bryan Donahue arguing.
- Janine Adams, Sandra's neighbor, told investigators that she thought Paul Digiovanni, Sandra's boyfriend, was also dating someone else who worked at the warehouse. However, Paul had an alibi—he was making a delivery 120 km away when the fire started.
- Bryan Donahue, Amery's ex-boyfriend, had talked to Sandra earlier in the day to ask whether she had any idea who Amery was seeing. Sandra didn't know, but she said she was beginning to suspect someone. She wouldn't tell him who, so they had indeed argued about it.
- According to Amery, Sandra's coworker and friend, Sandra had called her to come to the warehouse. It had been Amery's day off. When she arrived, she saw the flames and called for help. Worried about her friend, she tried to enter the building to get to her friend, but she couldn't get in.

After investigators finished questioning the witnesses, police were called to arrest the murderer.

### Activity:

Answer the following questions based on information in the *Crime Scene S.P.O.T.*

1. What evidence in the story indicates arson?
2. How would investigators process the evidence in this case?
3. Make a two-column chart. In the first column, list all of the possible suspects in the case. In the second column, describe motives they might have for setting the fire and killing Sandra Anderson.

WRITING



4. Using the clues in the story, write a conclusion to the story. In your conclusion, clearly describe the motive and explain how the evidence led to the suspect's arrest. You can be creative, but be sure that your conclusion is logical and that you demonstrate an understanding of arson investigation. Your conclusion should be 500 words or less.

# Preventing Adolescent Crime Together™ (P.A.C.T)

## Introduction:

Many arsonists are under the age of 18. In this activity, you will develop an arson awareness campaign for your school.

## Procedure:

1. Organize the class into groups of three or four students.
2. At the library or online, research the answers to the following questions about juvenile arson:
  - What are the most current statistics about arson? How many arson fires happen each year? How many are committed by juveniles?
  - What are some common motives in juvenile arson cases?
  - What characteristics are included in the behavioral profile of an adolescent arsonist?
  - What tips do experts offer for preventing adolescent arson?
  - Where can students and parents go to for help? Are there websites or telephone hotlines?
3. Using your group's research, make two posters and a pamphlet describing the dangers of fire and promoting fire prevention.



- Your group's posters should include a creative slogan that will capture the attention of your audience.
- Your group's informational pamphlet must be easy to read, informative, creative, and well organized. The pamphlet must be typed. Include charts and illustrations. Your teacher may distribute your pamphlet to students throughout the school.

**Figure 4-25.** Sample fire-prevention poster.

## ACTIVITY 4-1 *Ch. Obj: 4.7*

### SUPER SNIFFERS

#### Objectives:

By the end of this activity, you will be able to:

1. Recognize the value of using dogs to detect accelerants.
2. Use your sense of smell to make careful observations.

#### Materials:

(per group of four students)

6 film canisters, labeled A, B, C, D, E, and F

#### Safety Precautions:

No safety precautions are needed for this lab. However, proper procedures for detecting odors should be observed. Do not hold nose directly over canister. Use hand to waft the odor toward the nose.

#### Background:

An arson dog was brought in to investigate a fire in a local warehouse. Fire investigators and law-enforcement personnel think the business owner intentionally started the fire for the insurance money. The dog immediately began moving about the fire scene. Within minutes, the dog alerted his handler. When arson dogs detect the presence of an accelerant, they will either sit or bark at the origin of the odor. This behavior is called an *alert*. The alert tells investigators where to collect samples to analyze for the accelerant.

#### Procedure:

##### Day 1:

1. With one hand, hold canister A slightly below your nose, about 7 cm in front of your face. With your other hand, waft the air toward your nose. Canister A represents the accelerant odor.
2. Pay attention to any familiar odors or sensations.

##### Day 2:

1. Take turns wafting the scents from each of the canisters labeled B, C, D, E, and F.
2. Without discussing it with your partners, decide which of the canisters contains the same odor as canister A.

#### Questions:

1. After your teacher identifies which canister contains the same substance as canister A, use the following formula to calculate the percentage of students who correctly identified the sample.  
$$\frac{\text{Number of correct answers}}{\text{Number of students in class}} \times 100 = \underline{\hspace{2cm}} \% \text{ with correct answer}$$
2. How can you explain why not all students were able to correctly identify the scents? What factors made the process more difficult?
3. Why are dogs used to help investigators determine whether arson was a factor in a fire?







## ACTIVITY 4-2 Ch. Obj: 4.1

### EXOTHERMIC REACTIONS

#### Objectives:

By the end of this activity, you will be able to:

1. Determine the best proportion of chemicals to make an effective hot pack.
2. Explain exothermic reactions.
3. Properly collect, record, and interpret data.

#### Materials:

(per group of two students)

4 quart-size resealable freezer bags

permanent marker

triple beam balance

50 g  $\text{CaCl}_2$

50 g  $\text{NaHCO}_3$  (baking soda)

0.5 L distilled water

thermometer

watch or clock with a second hand

#### Safety Precautions:

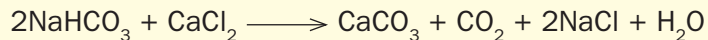
Wear safety goggles, gloves, and an apron when working with chemicals.

If you are allergic to latex, alert your teacher so that you may use alternative gloves.

Make sure long hair is pulled back and dangling jewelry is removed.

#### Background:

Baking soda ( $\text{NaHCO}_3$ ) and calcium chloride ( $\text{CaCl}_2$ ) combine to produce calcium carbonate ( $\text{CaCO}_3$ ), carbon dioxide ( $\text{CO}_2$ ), table salt ( $\text{NaCl}$ ), and water ( $\text{H}_2\text{O}$ ). The balanced chemical reaction is shown here:



The reaction is exothermic. This means that, as the reaction takes place, heat is released.



## Procedure:

1. Using the permanent marker, label the bags 1, 2, 3, and 4.
2. In bag 1, put 10 g of  $\text{CaCl}_2$  and 10 g of  $\text{NaHCO}_3$ .
3. Place the thermometer in the bag and read the initial temperature of the mixture. Record the initial temperature in your data table.
4. Add 100 mL of distilled water to the bag. Seal the bag around the thermometer. Record the time it takes for the hot pack to reach the maximum temperature. Record the maximum temperature.
5. Record how long the mixture remains at the maximum temperature.
6. Predict what would happen if the ratios of the compounds were changed. Design the remaining hot packs with three different ratios of  $\text{CaCl}_2$  and  $\text{NaHCO}_3$ . Be sure that your mixture includes a total of 20 g of  $\text{CaCl}_2$  and  $\text{NaHCO}_3$ . Record the contents of each bag in your data table.




Data Table. Observations.

	Amount of $\text{CaCl}_2$	Amount of $\text{NaHCO}_3$	Initial Temperature	Maximum Temperature	Time to Reach Max	Time Max Maintained
Bag 1						
Bag 2						
Bag 3						
Bag 4						

## Questions:

1. How did you predict the ratios would affect the results of your experiment? Was your prediction correct? Explain.
2. The recommended therapeutic temperature for a hot pack is not more than  $43^\circ\text{C}$ . Based on your experimental results, what is the best ratio of  $\text{CaCl}_2$  to  $\text{NaHCO}_3$  for use in a homemade hot pack?
3. What was the purpose of determining the initial temperature?
4. Which of the hot packs maintained the maximum temperature for the longest time?
5. Explain why the temperatures changed when the water was added.



## ACTIVITY 4-3 *Ch. Obj: 4.5, 4.6, 4.7, 4.9*

### INVESTIGATIONS

#### Objectives:

By the end of this activity, you will be able to:

1. Identify the correct procedure for searching a fire scene.
2. Evaluate investigative procedures.

#### Procedure:

Read the details of each case and answer the questions that follow.

#### CASE 1

Firefighters arrived at the scene of a fire at 10:00 p.m., on a Saturday. After the fire was out, investigators began to search the building. Because it was so dark, they decided to return in the morning to complete the investigation. The next day, fire investigators were able to determine that the fire had started in a storage room at the back of the store. The owner told investigators that he stored extra shipping boxes and crates as well as solvents used for his business in the room. He said he was certain that the solvents (mostly mineral spirits) had vaporized. He assumed that heat from the overhead fluorescent bulbs must have ignited the fumes, setting the cardboard and wood on fire. Fortunately, he had insured his business.

#### Questions:

1. If you were investigating the fire, what questions would you ask the owner?
2. Use information from the chapter to explain whether the owner's explanation is reasonable. Could heat from the fluorescent lights have ignited the fumes from the solvents?
3. Do you think the fire was accidental or intentional? Explain.
4. If you think that the fire was intentionally set, what do you think the motive was?

## CASE 2

On the morning after the fire, Jason Raines entered the building cautiously. This was his first investigation, and he was eager to get started. He systematically searched from room to room, taking notes, photographing the burn patterns, and collecting samples of debris. In the area where he found the most damage, he collected about 3 L of ash and debris. He placed the sample in an evidence envelope and properly documented the form. The fire had apparently started near the toaster in the kitchen. The plastic plug was melted, and there was severe damage around the outlet in a “V” pattern. The flames had apparently ignited the nearby curtains, and the fire had spread through the kitchen and into the dining room before firefighters arrived and extinguished the blaze.



### Questions:

1. Should the fire be classified as deliberate, accidental, natural, or undetermined? Why?
2. Did Jason Raines follow proper procedure for searching the scene? Explain.
3. What mistakes did Raines make? What should he have done instead?

### Extension:

**WRITING** Write your own fire investigation scenario. Add three or four questions about evidence collection and analysis, motive, or fire categories. Trade your scenario and questions with a partner.

