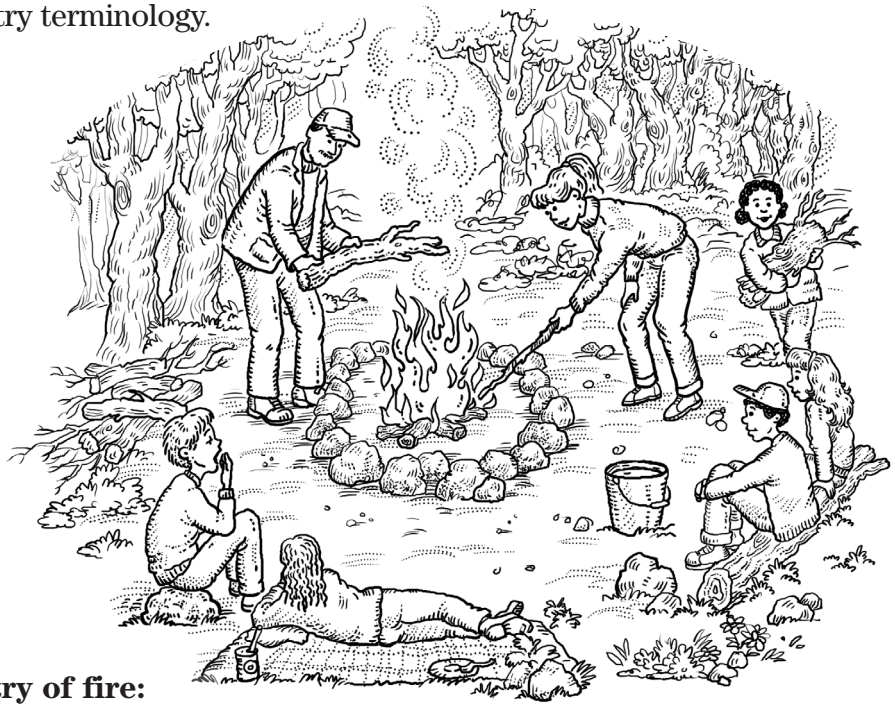
Understanding the Chemistry of Fire

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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Visit the American Red Cross Web site at *www.redcross.org/disaster/masters*

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?

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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Teen Gets Bad Burns

Name _____

Teen gets bad burns by kicking can of gas

He tried to keep others from harm at bonfire gathering.

BY CHUCK RUPNOW
Leader-Telegram staff

Josh Frie's unselfish act Saturday night likely prevented a group of friends from getting hurt at a bonfire, but resulted in second- and third-degree burns to himself.

Frie, 17, of rural Eau Claire, Wisconsin, was with a group of about 30 people at a nearby farm when gas was used to fuel a bonfire.

"Someone poured gas on it and set the gas can next to the fire," Frie said this morning from his hospital room at St. Paul-Ramsey Burn Center.

"They set it too close to the fire, and when they lit the fire, the gas can caught on fire," Frie said. "There were six or seven people standing right next to it, and I didn't want anyone to get hurt, so I kicked it away from them and gas went all over me."

Frie said he realized he was on fire and "started rolling and put myself out. When I got up, I was not on fire and told someone to take me home."

Frie was instead taken to Sacred Heart Hospital in Eau Claire and later transported to the burn center in St. Paul (MN), where initially he was listed in critical condition.

According to his mother, Connie Frie, his right arm was severely burned and will need skin grafting. She also said that there were severe burns to his chest, stomach, and the right side of his back.

Frie, a senior at Mondovi High School, is expected to be at the burn center for three to four weeks.

"Everybody came to see me at the hospital (Sacred Heart), and that was nice." Frie said. "I think there were more there than at the fire."

The Fries credited the school for proper instruction on what to do if someone catches fire. "It probably could have been worse otherwise," Connie Frie said. "Right now, recovery is one day at a time."

Eau Claire *Leader-Telegram,*
Eau Claire, Wisconsin,
September 30, 1996
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Fire-setting Statistics

Name _____

According to the National Fire Protection Association and the National Fire Incident Reporting System:

- 75 percent of all children know another child who has played with fire.
- Approximately 511,000 structure fires were reported in 2005.
- Children playing with fire caused an estimated 13,900 structure fires, with 210 deaths, 1,250 injuries and $339 million in direct damage in 2002.
- Most home fires caused by children playing with fire start with lighters or matches. **Note:** There has been a drop in fires started by children with lighters since 1994 and the introduction of the child-resistant lighter standard.
- The majority of fires caused by children playing with fire start in the bedroom.

According to the FBI and the Office of Juvenile Justice and Delinquency Prevention, approximately 60 to 80 percent of all intentionally set fires are set by juveniles. From 1993 to 2001, 50 percent of those arrested for arson were juveniles. (Local laws vary for the ages at which an adolescent is charged for arson as a juvenile).

Think About It

- One reason that many children play with fire is that children are curious. If we, as adults, talk to our children and teach them that fire is not something to play around with, they will be less likely to experiment with fire.

- Most of us are probably familiar with the term "peer pressure." What are some ways that we can help our children deal with peer pressure?

- Many of us have been—or possibly will be—tempted to leave our children unattended, usually for only a brief time. How should we deal with such situations? What are some things that we must remember if we ever consider leaving children unattended?

- If it is appropriate, please discuss your thoughts and strategies for helping children deal with peer pressure with other parents or adults in your family.

Sprinkler Systems

Name _____

Fire Sprinkler Facts

Fire sprinklers save lives, reduce property loss and can even help cut homeowner's insurance premiums.

Installing both smoke alarms and a fire sprinkler system reduces the risk of death in a home fire by 82 percent, compared with having neither.

In case of fire, only the sprinkler closest to the fire will activate, spraying water directly on the fire.

Ninety percent of fires are contained by the operation of just one sprinkler.

Nationally, on average, home fire sprinkler systems add 1 percent to 1.5 percent to the total cost of new construction.

Home fire sprinklers use only a fraction of the water used by fire department hoses.

The odds of accidental sprinkler discharge due to a manufacturing defect are 1 in 16 million.

Modern residential sprinklers are inconspicuous and can be mounted flush with walls or ceilings.

For more information visit the *Masters of Disaster* Web site at *www.redcross.org/disaster/masters*

Smoke Alarms

Name _____

What type should I buy?

There are two types of smoke alarms available:

1. **Photoelectric:** Uses a photoelectric bulb that sends forth a beam of light. When smoke enters, light from the beam is reflected from the smoke particles into a photocell and the alarm is triggered.

2. **Ionization chamber:** Contains a small, safe radiation source that produces electrically charged air molecules called ions. When smoke enters the chamber, it causes a change in the flow of ions, triggering the alarm.

Both are equally effective, and neither requires that you be familiar with its inner workings. As long as you buy an alarm that is tested by a major testing laboratory, such as Underwriters' Laboratories Inc. (UL), you can be assured it has met certain testing requirements.

Where should I install my alarm?

Smoke rises. So, the best place to install an alarm is on the ceiling or high on an inside wall just below the ceiling. If the ceiling is below an un-insulated attic or in a mobile home, the alarm should be placed on the wall 4 inches to 12 inches (10 centimeters to 30 centimeters) below the ceiling. Install alarms inside and outside each sleeping area, right outside the kitchen, and on every level of your home.

Remember:

- **Do not** install an alarm within 3 feet (92 centimeters) of an air supply register that might blow away the smoke.
- **Do not** install an alarm between an air return and the sleeping area. The smoke will be re-circulated and diluted, resulting in a delayed alarm.

If you are installing more than one alarm, you may want to consider purchasing units that can be interconnected. That way, when one unit detects smoke, all the alarms will sound. This is often required by newer building codes.

Smoke Alarms

How are alarms powered?

Alarms are powered two ways:

1. **Battery alarms** are the easiest to install. They require no outlets or wiring connection; however, batteries must be replaced once a year (approximately). All UL-listed battery-operated alarms are required to sound a trouble signal when a replacement is needed. The signal usually lasts seven days, so you should check the alarm if you have been away from your home for a week or more.

2. **Household current alarms** can be powered with household current two ways: They can be plugged into any wall socket or they can be wired permanently into your home's electrical system.

How can I best care for my alarms?

Everyone in the home who is old enough should take an active role in caring for the smoke alarms and making sure they work properly. Dirt, extreme changes in temperature, and cooking exhaust can cause a false alarm or malfunction of a smoke alarm. To prevent false alarms, locate the smoke alarm away from air vents, air conditioners and fans. Keep the grillwork free of dirt with occasional vacuuming and dusting. Do not paint them. Test your smoke alarm every 30 days, or more often if necessary, to make sure it is working. This is usually done with the test button. Change the batteries in your alarms at least once a year and replace alarms every 10 years because they become less sensitive over time.

Fire-suppression and Fire-warning Research

Name _____

Directions: Research fire-suppression and fire-warning devices to find the answers to the questions below. Record your data for each device on the sheet.

TOPIC: **Fire Alarms** **Smoke Alarms** **Sprinklers** **Flame Retardants**

What are they?

Why are they important?

How do they work?

How do they save lives?

How are they maintained?

What regulations are in place concerning their use?

Set up tasks for your group presentation. How can you most graphically depict the information for classmates?

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The Science of Fire Behavior

Name _____

HEAT AND TEMPERATURE

Often heat and temperature are thought to be the same—the greater the heat, the greater the temperature. However, the concepts are different. Consider these definitions:

Temperature is a measurement of the average internal kinetic energy or molecular motion of a substance. When measured on the absolute temperature scale, the Kelvin scale, this number is directly proportional to the average kinetic energy of the molecules.

Heat is energy and is defined as the total internal kinetic energy of a substance.

TEMPERATURES OF COMMON FIRES

Source of Ignition	General Temperature	
	CELSIUS	FAHRENHEIT
Cigarettes—ventilated conditions	400°–780°	752°–1436°
Cigarettes—unventilated conditions	288°	550°
Cigarettes—insulated and smoldering	510°–621°	950°–1150°
Match	600°–800°	1112°–1472°
Candle flame	600°–1400°	1112°–2550°
Stove element	550°	1022°
Fluorescent light	60°–80°	140°–176°
Incandescent light	100°–300°	212°–572°
Tungsten halogen light	600°–900°	1112°–1652°
Electrical arcing	to 3750°	to 6782°
Electrical spark	1316°	2401°
Lightning	30,000°	54032°
Oxyacetylene	3300°	5972°
Industrial furnaces	1700°	3092°
Bunsen burner	1570°	2858°

The Science of Fire Behavior

TEMPERATURE AND FLAME

Color of Flame at Different Temperatures	CELSIUS	FAHRENHEIT
DULL RED	500°–600°	932°–1112°
DARK RED	600°–800°	1112°–1472°
BRIGHT RED	800°–1000°	1472°–1832°
YELLOW RED	1000°–1200°	1832°–2192°
BRIGHT YELLOW	1200°–1400°	2192°–2552°
WHITE	1400°–1600°	2552°–2912°

SELECTED TEMPERATURES DURING BUILDING FIRES

	CELSIUS	FAHRENHEIT
Hot gas layer	600°–1000°	932°–1832°
Floor temperature	180°	356°
Glowing smoldering combustion	to 600°	to 1112°
Flashover	600°	1112°
Glowing coals	to 1300°	to 2372°

Heat Transfer

Heat can be transferred three ways:

- Conduction: direct contact between objects
- Convection: hot currents through liquid or gas
- Radiation: heat transferred by electromagnetic waves, such as infrared

Backdraft

Backdraft occurs when there is not enough oxygen to supply the flames. The fire smothers itself and waits for oxygen. When oxygen is provided by ventilation, the flames violently explode.

The Science of Fire Behavior

Flashover
Flashover is described as the "stage of the fire at which all surfaces and objects within the space have been heated to their ignition temperature, and flame breaks out almost at once over the surface of all objects in the space."*

The first phase of flashover results from the ignition of flammable gases produced by combustion (primarily carbon monoxide), which have accumulated in the upper parts of the fire area. As this happens, the radiant heat of the original fire is heating nearby combustibles—the walls, furniture, anything in the room—and these also begin giving off flammable gases. This is called **pyrolysis.** In this phase, smoke banks down quickly, reducing visibility dramatically.

The next phase of flashover is the **rollover,** or flaming, of these gases near the ceiling. This may appear in small flashes of flame and smoke or as a flame front rolling out across the ceiling. The fire has now changed from a steady-state fire to an aggressive, fast-moving fire.

The final phase is **thermal collapse.** Intense radiant heat pours down from all around. You can no longer get under the thermal balance (the stratified layer of heat and smoke). Intense heat drops to floor level.

Note: Firefighters will not enter a building if they think backdraft, flashover or thermal collapse is imminent.

**From the National Fire Protection Association, publication 921-35.3.2.*

Melting and Ignition Temperatures

Name _____

Directions: Different materials react differently in the presence of heat and flames. Some materials have a low ignition temperature and catch fire easily. Others almost never burn but do transfer heat. All materials, even steel, will burn or melt if the temperature gets high enough.

1. In the chart below are materials you commonly find in a residence. Use online or print resources or both to find out how these materials react to high temperatures.

Material	Melting or Ignition Temperature	In a Fire This Material Would Probably…
wood framing		
concrete		
plastic		
hardwood floors		
wool blanket		
steel		
wood paneling		
cotton curtains		
leather furniture		

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Visit the American Red Cross Web site at *www.redcross.org/disaster/masters*

Melting and Ignition Temperatures

2. After completing the chart, think of another material you might find in your home and find out how it will react in a fire.

What is the material?

_____

_____

_____

_____

How does it react?

_____

_____

_____

_____

_____

_____

_____

_____

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Fire Behavior and Firefighting Tactics

Name _____

Directions: Firefighters study the behavior of fires so they can rescue victims and extinguish the blaze effectively. On the left side of the chart below are several aspects of fire behavior. How do you believe these principles affect firefighting tactics? Put your ideas in the right column and be ready to discuss them.

Fire Behavior	Effect on Tactics
Convection Current	
Conduction of Heat by Non-combustibles	
Radiation of Heat Energy	
Flashover	
Backdraft	

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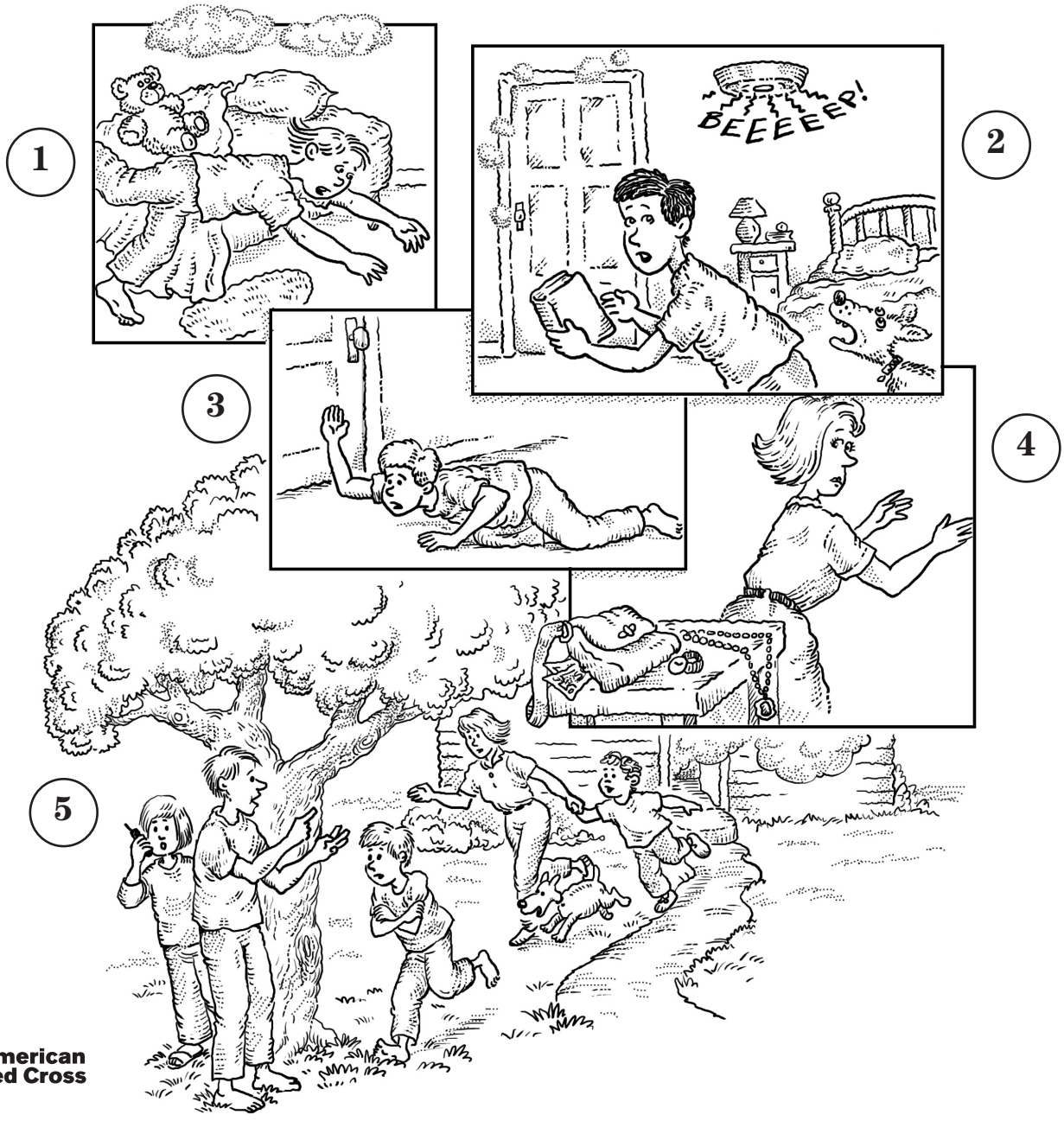
Identifying Safety Procedures to Follow During a Fire

Name _____

Directions: For each picture below, describe the correct safety procedures the people are following. State the reasoning for these actions based on your understanding of the behavior of fire. Be thorough.



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The Emotions of People Affected by a Fire

Name _____

Following a tragic event, a person's view of the world as a safe and predictable place is temporarily lost. The damage, injury and deaths that can result from an unexpected or uncontrollable event are difficult for most of us to understand.

It is rare that residential fires affect multiple families in the community in the way that large-scale human-caused and natural disasters do. However, the effects of a fire can be just as devastating. Sometimes, neighbors and friends of people who are affected by a fire may not be able to relate to the feelings or the losses caused by fire. Knowing about fires, what they do, and the emotions of those who have had a fire in their homes can help you understand how to empathize with and support someone who has been affected by a fire.

Questions to consider:

1. How might families dealing with the effects of fire feel different from families dealing with damage from the natural hazards that occur in your area—tornadoes, hurricanes, earthquakes, floods or lightning?

2. How might they feel similar?

3. How does going through the same situation with one or two people help you deal with your feelings?

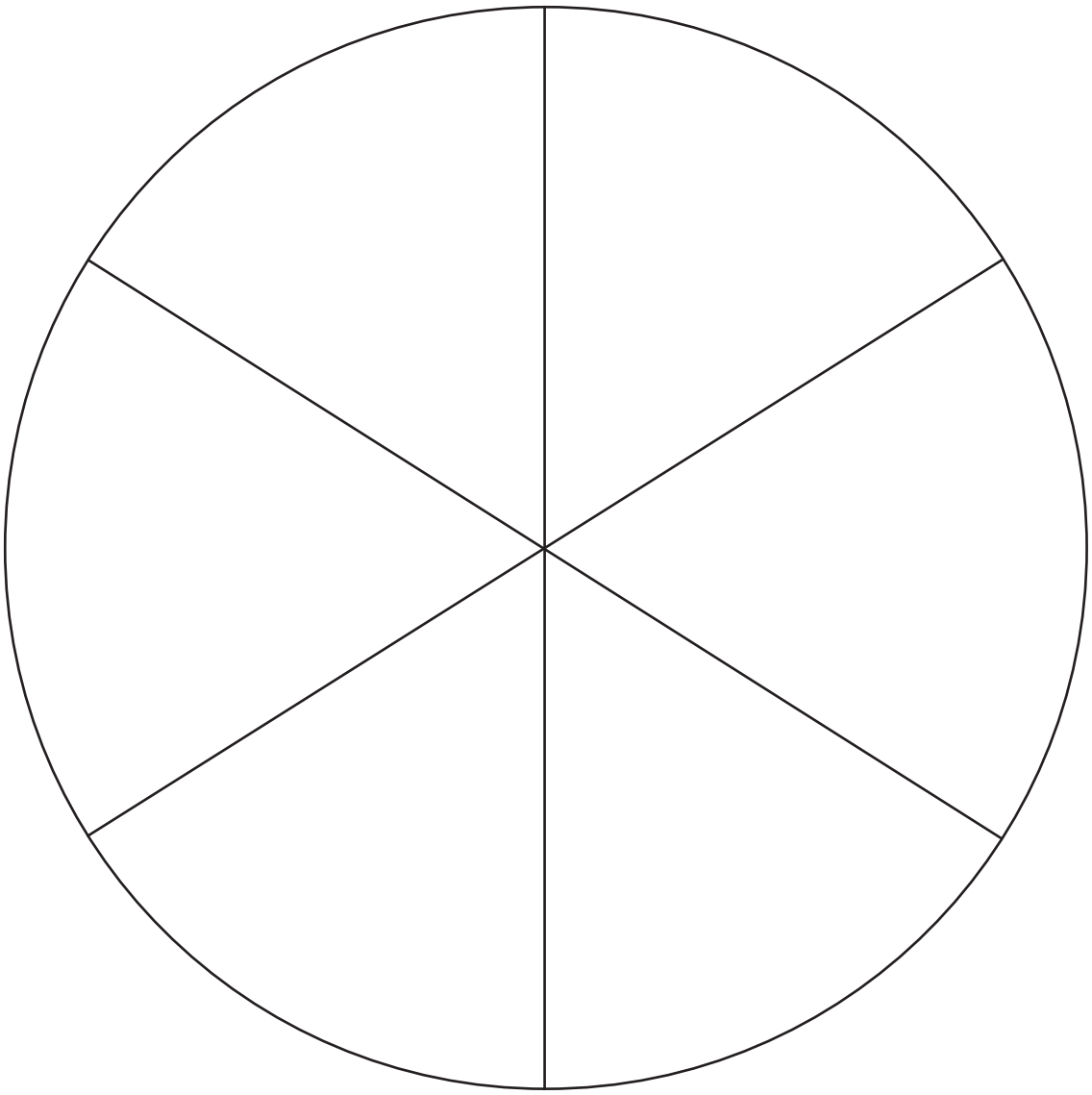
4. What can you do or say to help someone who has lost his or her home or belongings in a fire?

Note: Visit the Masters of Disaster Web site (*www.redcross.org/disaster/masters*) to link to more information about emotional reactions to fires.

Color Wheel

Name _____

Directions: Thinking about feelings is a good way to begin to understand them. Different colors often suggest particular feelings. Color every other wedge on the wheel below with a different primary pigment (red, yellow and blue). Then, color each of the remaining wedges with a different secondary pigment (orange, violet and green). Next to each color write words that the color evokes. How does color express your feelings?



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