Lesson 4

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What is a chemical property?
- What are some signs of chemical change?
- Why are chemical equations useful?
- What are some factors that affect the rate of chemical reactions?

Vocabulary

chemical property p. 256

chemical change p. 257

concentration p. 260

Multilingual eGlossary

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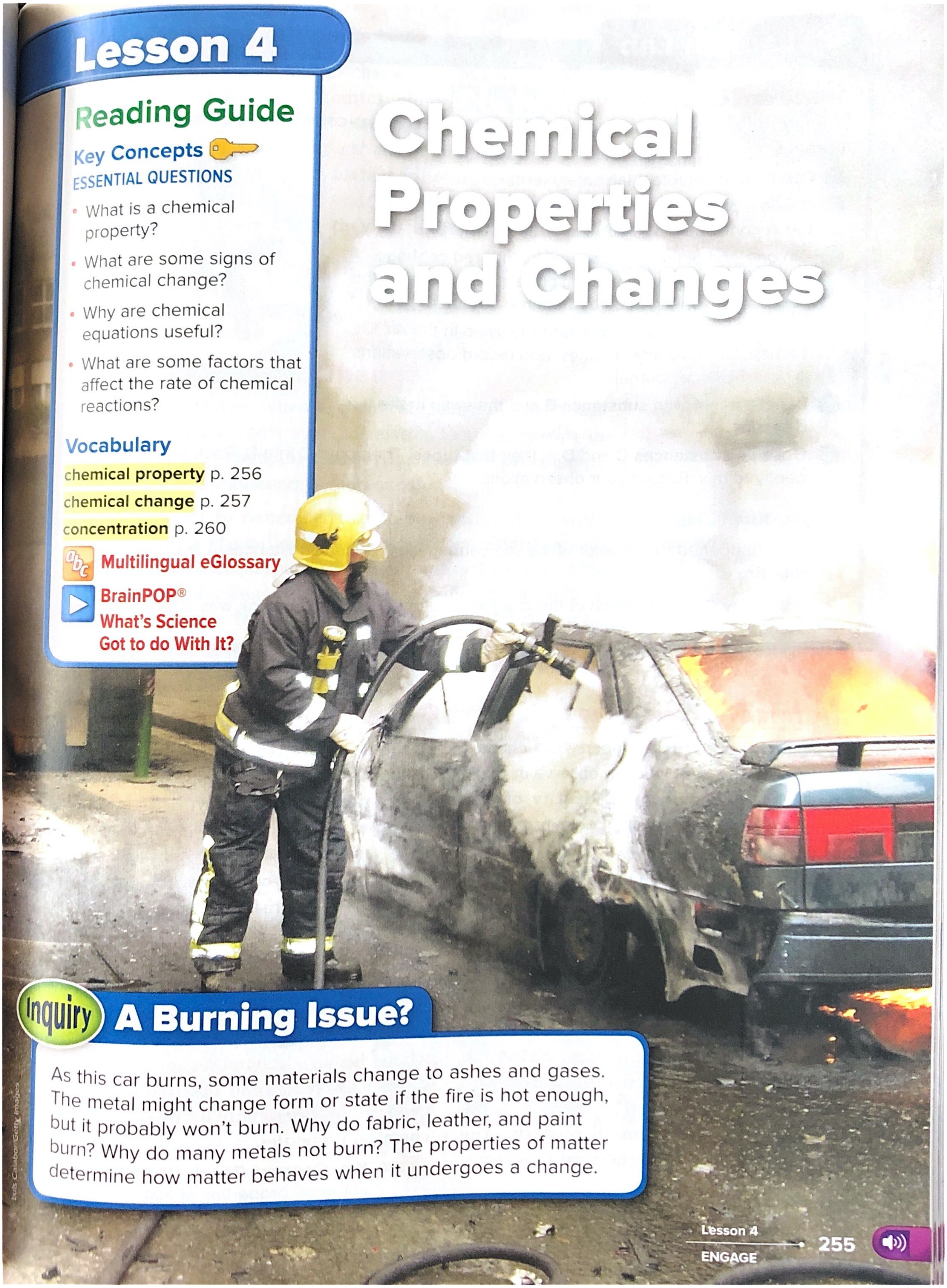
What's Science Got to do With It?

Chemical Properties and Changes



Luis Calabor/Getty Images

Inquiry A Burning Issue?

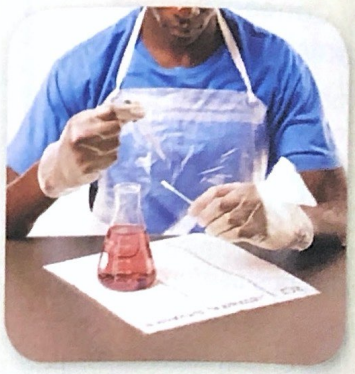
As this car burns, some materials change to ashes and gases. The metal might change form or state if the fire is hot enough, but it probably won't burn. Why do fabric, leather, and paint burn? Why do many metals not burn? The properties of matter determine how matter behaves when it undergoes a change.

Launch Lab

15 minutes

What can colors tell you?

You mix red and blue paint to get purple paint. Iron changes color when it rusts. Are color changes physical changes?



1. Read and complete a lab safety form.
2. Divide a **paper towel** into thirds. Label one section *RCJ*, the second section *A*, and the third section *B*.
3. Dip one end of three **cotton swabs** into **red cabbage juice** (RCJ). Observe the color, and set the swabs on the paper towel, one in each of the three sections.
4. Add one drop of **substance A** to the swab in the *A* section. Observe any changes, and record observations in your Science Journal.
5. Repeat step 4 with **substance B** and the swab in the *B* section.
6. Observe **substances C** and **D** in their **test tubes.** Then pour C into D. Rock the tube gently to mix. Record your observations.

Think About This

1. What happened to the color of the red cabbage juice when substances A and B were added?
2. **Key Concept** Which of the changes you observed do you think was a physical change? Explain your reasoning.

Chemical Properties

Recall that a physical property is a characteristic of matter that you can observe or measure without changing the identity of the matter. However, matter has other properties that can be observed only when the matter changes from one substance to another. *A* **chemical property** *is a characteristic of matter that can be observed as it changes to a different type of matter.* For example, what are some chemical properties of a piece of paper? Can you tell by just looking at it that it will burn easily? The only way to know that paper burns is to bring a flame near the paper and watch it burn. When paper burns, it changes into different types of matter. The ability of a substance to burn is a chemical property. The ability to rust is another chemical property.

Comparing Properties

You now have read about physical properties and chemical properties. All matter can be described using both types of properties. For example, a wood log is solid, rounded, heavy, and rough. These are physical properties that you can observe with your senses. The log also has mass, volume, and density, which are physical properties that can be measured. The ability of wood to burn is a chemical property. This property is obvious only when you burn the wood. It also will rot, another chemical property you can observe when the log decomposes, becoming other substances. When you describe matter, you need to consider both its physical and its chemical properties.

Key Concept Check What are some chemical properties of matter?

Chemical Changes

Recall that during a physical change, the identity of matter does not change. However, *a* **chemical change** *is a change in matter in which the substances that make up the matter change into other substances with new physical and chemical properties.* For example, when iron undergoes a chemical change with oxygen, rust forms. The substances that undergo a change no longer have the same properties because they no longer have the same identity.

Reading Check What is the difference between a physical change and a chemical change?

Signs of Chemical Change

How do you know when a chemical change occurs? What signs show you that new types of matter form? As shown in Figure 16, signs of chemical changes include the formation of bubbles or a change in energy, odor, or color.

It is important to remember that these signs do not always mean a chemical change occurred. Think about what happens when you heat water on a stove. Bubbles form as the water boils. In this case, bubbles show that the water is changing state, which is a physical change. The evidence of chemical change shown in Figure 16 means that a chemical change might have occurred. However, the only proof of chemical change is the formation of a new substance.

Key Concept Check What are signs of a chemical change?

FOLDABLES®

Use a sheet of paper to make a chart with four columns. Use the chart throughout this lesson to explain how the identity of matter changes during a chemical change.

Action/ Matter	Signs of Chemical Change	Explain the Chemical Reaction	What affects the reaction rate?

WORD ORIGIN

chemical
from Greek *chemeia,* means "cast together"

Some Signs of Chemical Change

Figure 16 Sometimes you can observe clues that a chemical change has occurred.

Bubbles

Energy change

Odor change

Color change

Visual Check What signs show that a chemical change takes place when fireworks explode?

MiniLab 20 minutes

Can you spot the clues for chemical change?

What are some clues that let you know a chemical change might have taken place?

1. Read and complete a lab safety form.
2. Add about 25 mL of room-temperature water to a **self-sealing plastic bag.** Add two **dropperfuls** of **red cabbage juice.**
3. Add one **measuring scoop** of **calcium chloride** to the bag. Seal the bag. Tilt the bag to mix the contents until the solid disappears. Feel the bottom of the bag. Record your observations in your Science Journal.
4. Open the bag, and add one measuring scoop of **baking soda.** Quickly press the air from the bag and reseal it. Tilt the bag to mix the contents. Observe for several minutes. Record your observations.

Analyze and Conclude

1. **Observe** What changes did you observe?
2. **Infer** Which of the changes suggested that a new substance formed? Explain.
3. **Key Concept** Are changes in energy always a sign of a chemical change? Explain.

Explaining Chemical Reactions

You might wonder why chemical changes produce new substances. Recall that particles in matter are in constant motion. As particles move, they collide with each other. If the particles collide with enough force, the bonded atoms that make up the particles can break apart. These atoms then rearrange and bond with other atoms. When atoms bond together in new combinations, new substances form. This process is called a reaction. Chemical changes often are called chemical reactions.

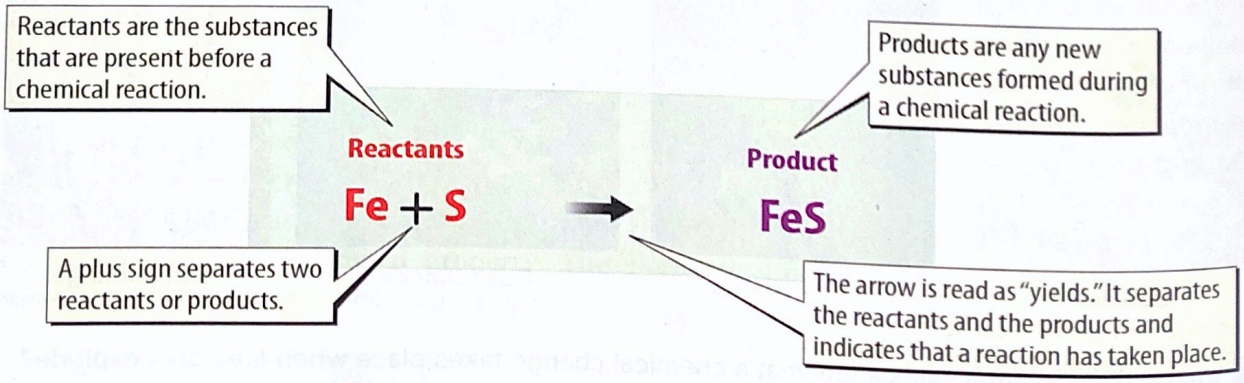
Reading Check What does it mean to say that atoms rearrange during a chemical change?

Using Chemical Formulas

A useful way to understand what happens during a chemical reaction is to write a chemical equation. A chemical equation shows the chemical formula of each substance in the reaction. The formulas to the left of the arrow represent the reactants. Reactants are the substances present before the reaction takes place. The formulas to the right of the arrow represent the products. Products are the new substances present after the reaction. The arrow indicates that a reaction has taken place.

Key Concept Check Why are chemical equations useful?

Figure 17 Chemical formulas and other symbols are parts of a chemical equation.



Balancing Chemical Equations

Look at the equation in **Figure 17.** Notice that there is one iron (Fe) atom on the reactants side and one iron atom on the product side. This is also true for the sulfur (S) atoms. Recall that during both physical and chemical changes, mass is conserved. This means that the total mass before and after a change must be equal. Therefore, in a chemical equation, the number of atoms of each element before a reaction must equal the number of atoms of each element after the reaction. This is called a balanced chemical equation, and it illustrates the law of conservation of mass. **Figure 18** explains how to write and balance a chemical equation.

When balancing an equation, you cannot change the chemical formula of any reactants or products. Changing a formula changes the identity of the substance. Instead, you can place coefficients, or multipliers, in front of formulas. Coefficients change the amount of the reactants and products present. For example, an H_2O molecule has two H atoms and one O atom. Placing the coefficient *2* before H_2O ($2H_2O$) means that you double the number of H atoms and O atoms present:

2×2 H atoms = 4 H atoms
2×1 O atom = 2 O atoms

Note that $2H_2O$ is still water. However, it describes two water particles instead of one.

Figure 18 Equations must be balanced because mass is conserved during a chemical reaction.

Balancing Chemical Equations

Personal Tutor

Balancing Chemical Equations Example

When methane (CH_4)—a gas burned in furnaces—reacts with oxygen (O_2) in the air, the reaction produces carbon dioxide (CO_2) and water (H_2O). Write and balance a chemical equation for this reaction.

1 Write the equation, and check to see if it is balanced.

a. Write the chemical formulas with the reactants on the left side of the arrow and the products on the right side.

b. Count the atoms of each element in the reactants and in the products.
- Note which elements have a balanced number of atoms on each side of the equation.
- If all elements are balanced, the overall equation is balanced. If not, go to step 2.

a. $CH_4 + O_2 \rightarrow CO_2 + H_2O$ **not balanced**

b. reactants → products

C=1	C=1	**balanced**
H=4	H=2	**not balanced**
O=2	O=3	**not balanced**

2 Add coefficients to the chemical formulas to balance the equation.

a. Pick an element in the equation whose atoms are not balanced, such as hydrogen. Write a coefficient in front of a reactant or a product that will balance the atoms of the chosen element in the equation.

b. Recount the atoms of each element in the reactants and the products, and note which are balanced on each side of the equation.

c. Repeat steps 2a and 2b until all atoms of each element in the reactants equal those in the products.

a. $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$ **not balanced**

b. reactants → products

C=1	C=1	**balanced**
H=4	H=4	**balanced**
O=2	O=4	**not balanced**

c. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ **balanced**

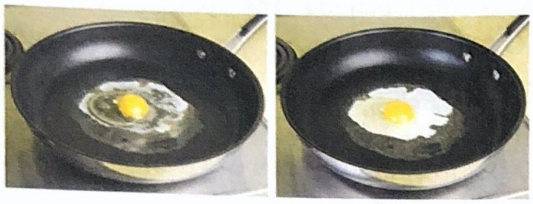
C=1	C=1	**balanced**
H=4	H=4	**balanced**
O=4	O=4	**balanced**

3 Write the balanced equation that includes the coefficients: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Factors that Affect the Rate of Chemical Reactions

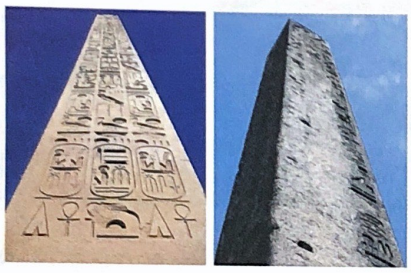
Figure 19 The rate of most chemical reactions increases with an increase in temperature, concentration, or surface area.

1 Temperature



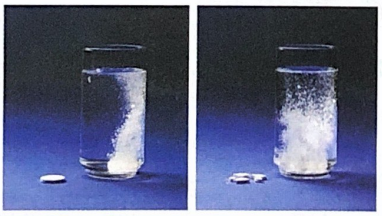
Chemical reactions that occur during cooking happen at a faster rate when temperature increases.

2 Concentration



Acid rain contains a higher concentration of acid than normal rain does. As a result, a statue exposed to acid rain is damaged more quickly than a statue exposed to normal rain.

3 Surface Area



When an antacid tablet is broken into pieces, the pieces have more total surface area than the whole tablet does. The pieces react more rapidly with water because more of the broken tablet is in contact with the water.

The Rate of Chemical Reactions

Recall that the particles that make up matter are constantly moving and colliding with one another. Different factors can make these particles move faster and collide harder and more frequently. These factors increase the rate of a chemical reaction, as shown in **Figure 19.**

1 A higher temperature usually increases the rate of reaction. When the temperature is higher, the particles move faster. Therefore, the particles collide with greater force and more frequently.

2 **Concentration** is the *amount of substance in a certain volume.* A reaction occurs faster if the concentration of at least one reactant increases. When concentration increases, there are more particles available to bump into each other and react.

3 Surface area also affects reaction rate if at least one reactant is a solid. If you drop a whole effervescent antacid tablet into water, the tablet reacts with the water. However, if you break the tablet into several pieces and then add them to the water, the reaction occurs more quickly. Smaller pieces have more total surface area, so more space is available for reactants to collide.

Key Concept Check List three factors that affect the rate of a chemical reaction.

Chemistry

To understand chemistry, you need to understand matter. You need to know how the arrangement of atoms results in different types of matter. You also need to be able to distinguish physical properties from chemical properties and describe ways these properties can change. In later chemistry chapters and courses, you will examine each of these topics closely to gain a better understanding of matter.

Lesson 4 Review

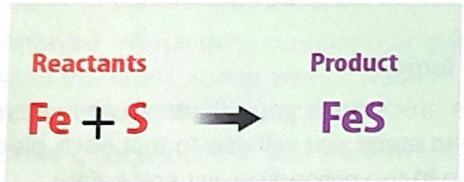
Online Quiz

Visual Summary

A chemical property is observed only as a material undergoes chemical change and changes identity.

Signs of possible chemical change include bubbles, energy change, and change in odor or color.

Chemical equations show the reactants and products of a chemical reaction and that mass is conserved.



FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

7. When wood burns, new materials form.

8. Temperature can affect the rate at which chemical changes occur.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. The amount of substance in a certain volume is its _____.
2. **Use the term** *chemical change* in a complete sentence.

Understand Key Concepts

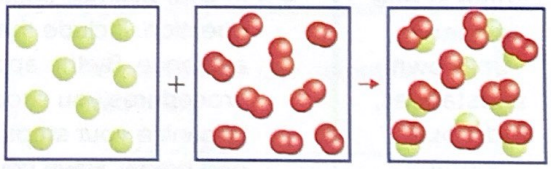
3. **List** some signs of chemical change.
4. Which property of matter changes during a chemical change but does NOT change during a physical change?

   A. energy **C.** mass
   B. identity **D.** volume

5. **State** why chemical equations are useful.
6. **Analyze** What affects the rate at which acid rain reacts with a statue?

Interpret Graphics

7. **Examine** Explain how the diagram below shows conservation of mass.



8. **Compare and Contrast** Copy and fill in the graphic organizer to compare and contrast physical and chemical changes.

Physical and Chemical Changes	
Alike	
Different	

Critical Thinking

9. **Compile** a list of three physical changes and three chemical changes you have observed recently.
10. **Recommend** How could you increase the rate at which the chemical reaction between vinegar and baking soda occurs?

Lab

1–2 class periods

Design an Experiment to Solve a Crime

Materials

triple-beam balance

50-mL graduated cylinder

magnifying lens

bar magnet

Also needed: crime scene evidence, unknown substances, dropper bottles containing water, iodine, cornstarch, and red cabbage indicator, test tubes, test tube rack, stirring rod

Safety

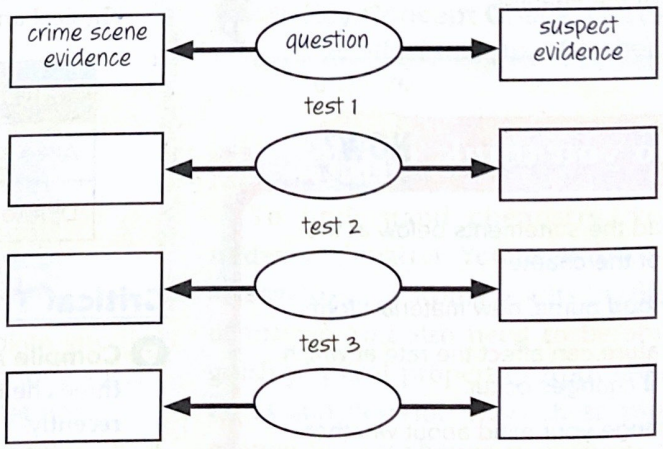
Recall how you can use properties to identify and compare substances. You now will apply those ideas to solving a crime. You will be given evidence collected from the crime scene and from the suspect's house. As the investigator, decide whether evidence from the crime scene matches evidence from the suspect. What tests will you use? What does the evidence tell you?

Question

Determine which factors about the evidence you would like to investigate further. Consider how you can describe and compare the properties of each piece of evidence. Evaluate the properties you will observe and measure, and decide whether it would be an advantage to classify them as physical properties or chemical properties. Will the changes that the evidence will undergo be helpful to you? Think about controls, variables, and the equipment you have available. Is there any way to match samples exactly?

Procedure

1. Read and complete a lab safety form.
2. In your Science Journal, write the procedures you will use to answer your question. Include the materials and steps you will use to test each piece of evidence. By the appropriate step in the procedure, list any safety procedures you should observe while performing the investigation. Organize your steps by putting them in a graphic organizer, such as the one below. Have your teacher approve your procedures.



3. Begin by observing and recording your observations on each piece of evidence. What can you learn by comparing physical properties? Are any of the samples made of several parts?
4. Use the available materials to test the evidence. Accurately record all observations and data for each piece of evidence.
5. Add any additional tests you think you need to answer your questions.

Analyze and Conclude

6. **Examine** the data you have collected. What does the evidence tell you about whether the crime scene and the suspect are related?
7. **Formulate** Write your conclusions in your Science Journal. Be thorough because these are the notes you would use if you had to testify in court about the case.
8. **Analyze** Which data suggest that evidence from the crime scene was or wasn't connected to the suspect?
9. **Draw Conclusions** If you were to testify in court, what conclusions would you be able to state confidently based on your findings?
10. **The Big Idea** How does understanding physical and chemical properties of matter help you to solve problems?

Communicate Your Results

Compare your results with those of other teams. Discuss the kinds of evidence that might be strong enough to convict a suspect.

Inquiry Extension

Research the difference between individual and class evidence used in forensics. Decide which class of evidence your tests provided.

Lab Tips

- ☑ Don't overlook simple ideas such as matching the edges of pieces.
- ☑ Can you separate any of the samples into other parts?
- ☑ Always get your teacher's approval before trying any new test.

Remember to use scientific methods.