CALIFORNIA Standards Preview

Standard Set 1. Physical Sciences

1. Elements and their combinations account for all the varied types of matter in the world. As a basis for understanding this concept:

1.a. *Students know* that during chemical reactions the atoms in the reactants rearrange to form products with different properties.

1.c. *Students know* metals have properties in common, such as high electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag), and gold (Au), are pure elements; others, such as steel and brass, are composed of a combination of elemental metals.

1.f. *Students know* differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.

1.g. *Students know* properties of solid, liquid, and gaseous substances, such as sugar ($C_6H_{12}O_6$), water (H_2O), helium (He), oxygen (O_2), nitrogen (N_2), and carbon dioxide (CO_2).

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Draw Conclusions	• Captions • Charts • Labels • Glossary	Changes in Matter

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California Science Explorer

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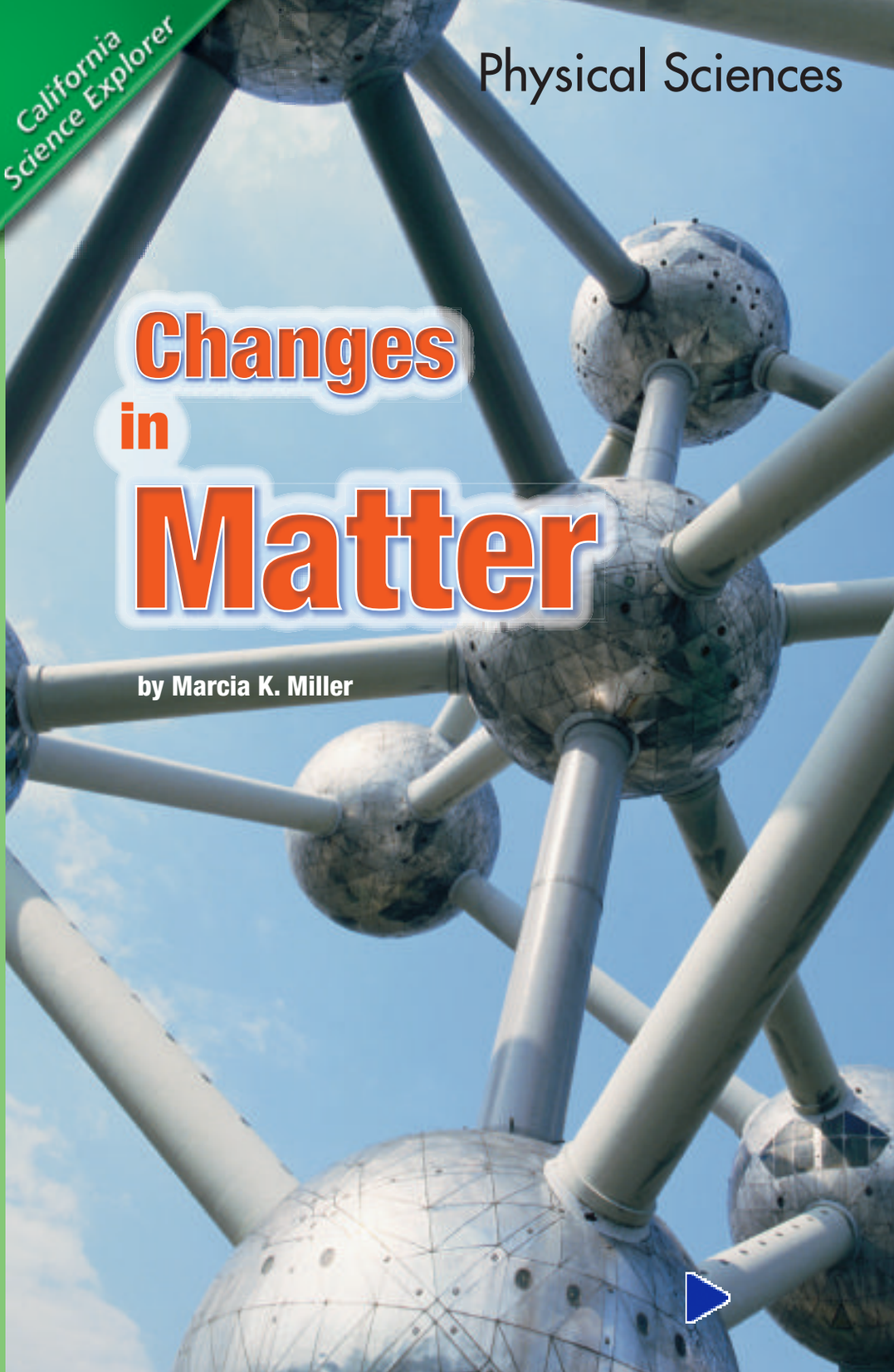
Physical Sciences

Changes in Matter

by Marcia K. Miller



Vocabulary

chemical change
chemical equation
condensation
evaporation
physical change
product
reactant
sublimation

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What are physical and chemical changes?

Physical Changes

In a **physical change,** matter keeps the same chemical properties. Physical changes include changes in the size, shape, volume, and state of matter. Falling rain may start as drops. The drops can freeze into hard sleet. Raindrops and sleet have different sizes, shapes, volumes, and states of matter. But both are forms of water.

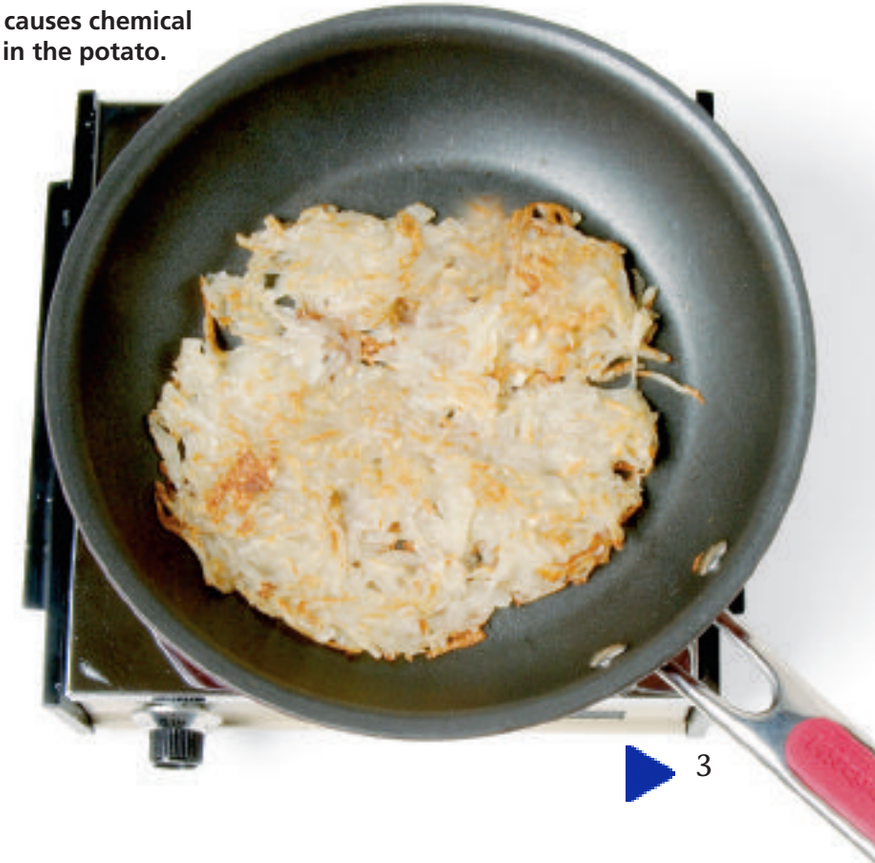
Tearing paper, sawing wood, grating a potato, and melting wax are all physical changes. Some physical changes can surprise you. Salt crystals seem to disappear in water. But the salt is still there. Salt crystals will appear again if you let the water evaporate.

Peeling and grating are two kinds of physical changes.

Chemical Changes

In a **chemical change,** one kind of matter changes into a different kind of matter with different properties. Cooking makes foods go through chemical changes. A cooked potato doesn't taste or smell like a raw one.

In a chemical change atoms rearrange themselves to form other kinds of matter. It's not always easy to know when a chemical change occurs. You can learn some of the clues to this kind of change. Chemical changes may cause heat, light, or sound. Iron is usually gray. Rust is red-orange. A color change is a hint of a chemical change. Rust is a new material. It has different properties than iron.



Cooking causes chemical changes in the potato.

Evidence of Chemical Changes

Chemical changes often produce a gas or a solid. The pictures on page 5 show some of the steps in a chemical change. Copper wires are twisted together into a tree shape. The copper tree is then put into a chemical solution. A chemical change makes solid crystals form on the tree. Crystals cling to the wires. These solid crystals prove that a chemical change took place.

Burning is another chemical change. Look at the picture of the candle. The candle and the oxygen in the air both go through this chemical change. The process of burning creates three new substances. They are ash, carbon dioxide gas, and water vapor. All of these substances have different properties from the candle and the oxygen.

When wax melts, it is a physical change. When the wax and wick burn, they go through chemical changes.

This tree is made of copper wires bent together.

The jar has a chemical solution in it. The copper tree is put into the solution.

There has been a chemical change. Solid crystals grew on the copper tree. The crystals were formed by a chemical reaction. The liquid changed from clear to blue.

How does matter change state?

States of Matter: Solids And Liquids

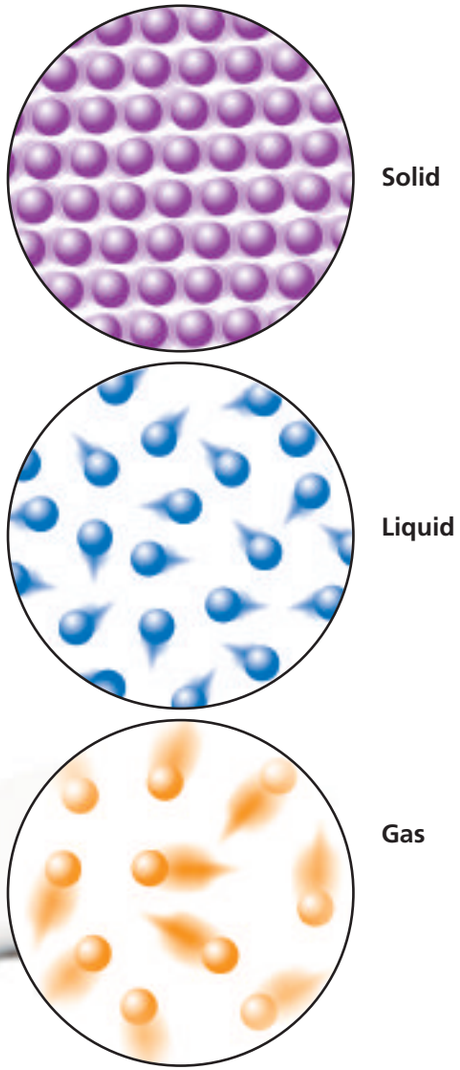
Water has three forms. Water is a liquid in rivers and seas. It is a solid when it is frozen as ice. It is a gas in the air. These three forms are called phases or states of matter. The phase of any material is the result of the motions and positions of its molecules or atoms. The state of a material at room temperature is a physical property.

A solid has volume and shape. The particles in most solids are very close together. They vibrate in place. Forces between the particles keep them from moving apart.

A solid melts into a liquid as it warms up. The particles no longer vibrate in one place. Forces between particles hold them close together, but the particles can move and flow. Liquids do not have their own shape. They take the shape of their container. Liquids have a definite volume.

States of Matter: Gases

The particles of a gas are far apart, with more space between them than between the particles of a liquid or a solid. Gas particles can be squeezed more than the particles of solids or liquids can be. Gas particles generally do not affect one another unless they hit each other. They spread out evenly in a container. Therefore, a gas has no definite shape or volume.



Freezing and Melting

If a liquid gets cold enough, it may freeze. The liquid turns into a solid. The frozen particles slow down. They vibrate in place. There are two names for the point at which matter changes from a solid to a liquid. The freezing point is the temperature at which a liquid becomes a solid. The melting point is the temperature at which a solid becomes a liquid.

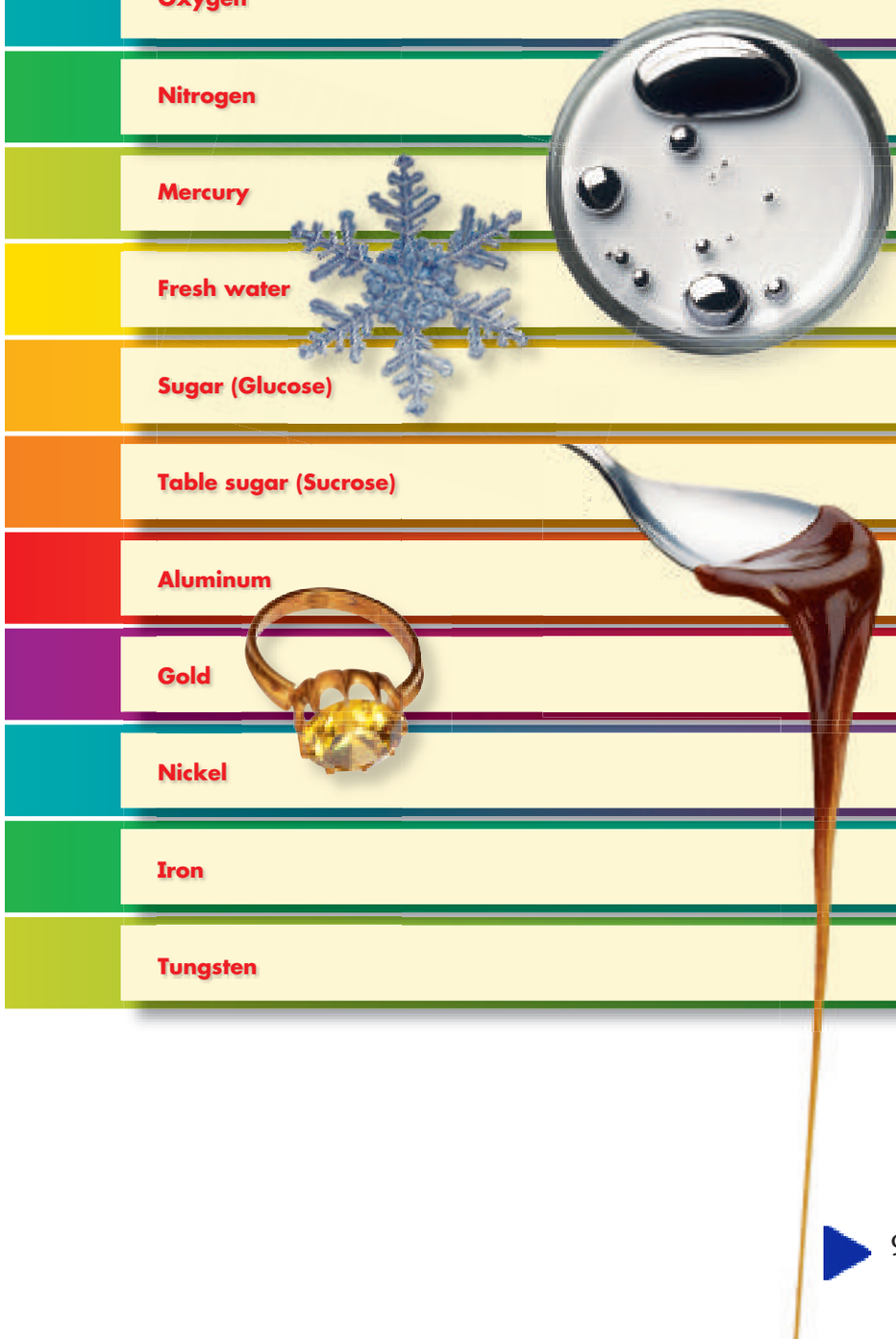
The melting point is a physical property of all matter. You can use this property to help identify matter. A melting point is the same for any amount of a material. But the melting point may change if things are added to a material. You can raise the melting point of ice by adding salt to it. Saltwater freezes at a lower temperature than fresh water does.

Particles in Motion

Materials change size as they change in temperature. But no new material is made or destroyed. Particles always move. They move faster as a material heats up. Fast-moving particles usually have more space between them. The extra space lets the material get a bit larger. You can see this in a thermometer. The liquid in the glass tube expands as it warms up.

Materials may get a little smaller as they cool off. Cold particles move more slowly. They have less space between them. The particles can never get cold enough to stop vibrating.

Material	Melting Temperature
Oxygen	–218°C
Nitrogen	–210°C
Mercury	–39°C
Fresh water	0°C
Sugar (Glucose)	146°C
Table sugar (Sucrose)	185°C
Aluminum	660°C
Gold	1063°C
Nickel	1453°C
Iron	1535°C
Tungsten	3410°C



Evaporation

Evaporation takes place when particles leave a liquid and become a gas. Speed helps the particles of a liquid to evaporate. They must move upward fast enough to overcome the forces at the surface.

Particles can evaporate everywhere in a liquid, not just at the surface. This happens if the temperature of the liquid is hot enough. As gas particles move up through a liquid, gas bubbles form under the surface. The boiling point of a liquid is the temperature at which the liquid turns into these gas bubbles throughout the liquid.

The boiling point is a physical property. The boiling point of a liquid is the same, no matter how much of it is heated. You can use the boiling point to help identify a liquid.

Liquid can evaporate even if its temperature does not reach the boiling point. This is what makes your wet clothes get dry.

Water vapor is invisible. When you see steam, you are seeing tiny water drops that form during condensation.

Condensation

Condensation takes place when a gas turns into a liquid. This process often takes place when gas particles touch a cold surface. This makes their temperature drop. The particles slow down. They get trapped by the forces at the surface. As more and more gas particles get trapped, they form a liquid drop. Condensation forms the clouds in the sky and the dew on the ground.

Sublimation

Sublimation takes place when some solids change directly to gases without first turning into liquids. Carbon dioxide is known as dry ice when it is in its solid form. Dry ice can exist only when temperatures fall below -78.5°C. At -78.5°C., the particles in dry ice begin moving very fast. They escape from the solid as a gas. They skip the liquid phase.

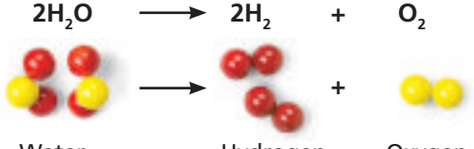
Material	Boiling Point
Helium	–268.9°C
Nitrogen	–195.8°C
Oxygen	–183°C
Chlorine	–34°C
Fresh water	100°C
Mercury	357°C
Aluminum	2467°C

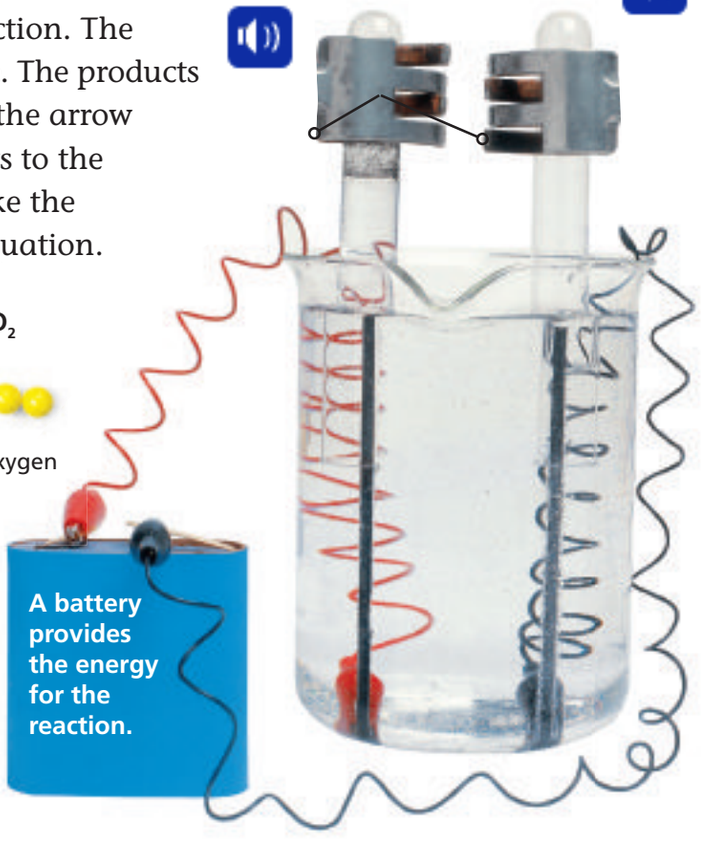
What are some kinds of chemical reactions?

Chemical Equations

Substances change into other substances when there is a chemical reaction. A substance used in the reaction is called a **reactant.** A substance made by the reaction is called a **product.** The atoms of reactants rearrange to form the new products. The new products have different properties than the reactants.

A **chemical equation** shows what happens in a chemical reaction. The reactants are on the left side. The products are on the right side. Read the arrow that goes from the reactants to the products as "makes." It's like the equal sign (=) in a math equation.





Magnesium and oxygen are reactants. Bright light and heat are evidence of a reaction.

Chemical Reactions

Magnesium is a silvery metal. It is often used in fireworks. At a high temperature, magnesium reacts with oxygen in the air. It burns with a bright white glow. This chemical reaction forms a white powder. The powder, called magnesium oxide, is the product of the reaction.

Matter Is Always Conserved

A chemical reaction cannot create or destroy matter. This fact is called the Law of Conservation of Mass. It says that the total mass of the reactants equals the total mass of the products. Suppose you bake a cake. The mass of all the ingredients equals the mass of the cake plus the mass of the water vapor, carbon dioxide, and other trace gases that float up from the oven. The trace gases give the cake its great smell!

Types of Chemical Reactions

There are many kinds of chemical reactions. You can use a model to make a chemical reaction easier to understand. Of course a model isn't the real thing. But a good model can teach you about the real thing. Think about trucks and trailers as models of atoms in different kinds of reactions.

In a decomposition reaction, compounds split apart to form smaller compounds or elements. Picture a truck being unhitched from a trailer. The picture on page 12 shows this kind of reaction. When water molecules break apart there are two products: hydrogen and oxygen gases.

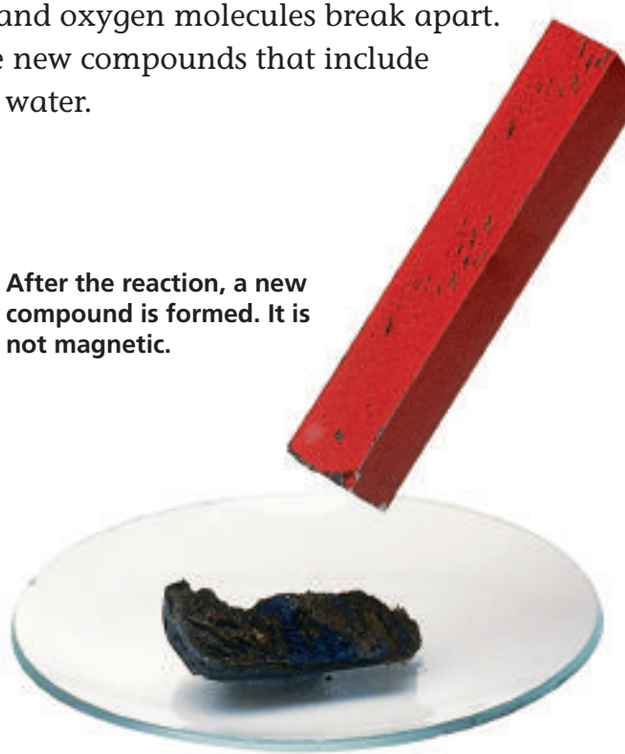
Elements or compounds can come together to form new compounds in a combination reaction. Picture a truck being attached to a trailer. A combination reaction takes place between iron and sulfur. The two reactants produce a compound called iron sulfide.

Before the reaction, iron is a dark magnetic material.

Sulfur is a yellow powder. It is not magnetic.

More Chemical Reactions

Another kind of chemical reaction is a replacement reaction. One or more compounds split apart. The parts then switch places. You can picture two trucks switching trailers. A replacement reaction takes place when a candle burns. Some candle waxes are long molecules of carbon and hydrogen atoms. You have read that oxygen gas is a molecule made of two oxygen atoms. When wax burns, the long molecules and oxygen molecules break apart. They rejoin to make new compounds that include carbon dioxide and water.



After the reaction, a new compound is formed. It is not magnetic.

Examples of Chemical Reactions

All chemical changes take place during chemical reactions. In a chemical reaction, atoms in the reactants reorganize into products that have different properties. No atoms are lost. No new atoms are added. Atoms combine in new ways to form a new substance.

Look at the chart. It shows how atoms rearrange in the three types of chemical reactions you have read about. Rust forms as a result of a combination reaction. Imagine that the open circle in the chart is iron. The red circle is oxygen. A new product forms from both kinds of circles when the substances combine. The product is iron oxide, or rust.

Rust forms on chains through a combination reaction between iron and oxygen.

Type of Reaction	Model
Decomposition	
Combination	
Replacement	

More Examples of Chemical Reactions

Look at the photo of a chemical change. Two colorless liquids were mixed together. One of the new products that formed is the yellow substance you see. The other new product dissolves in the water so you can't see it. What type of reaction has taken place?

As it turns out, this is a replacement reaction. Find the model of the replacement reaction in the chart on page 16. It shows that particles from the different substances switch places in a replacement reaction. This is how new substances can form.

Have you ever seen an adult put hydrogen peroxide on a cut? Hydrogen peroxide is a clear liquid. It is made of hydrogen and oxygen. It can break into water and oxygen gas in a decomposition reaction. One substance breaks apart to form new substances.

Two colorless liquids were mixed. A yellow substance formed. This shows that a chemical change took place.

Hydrogen peroxide is a compound. Its chemical name is H_2O_2.

How are chemical properties used?

Separating Mixtures

Chemical properties can separate some mixtures. Scientists use chemical properties to separate fossils from the rock that holds them. Fossils often form in limestone. It is hard to remove limestone from a fossil without harming it. Vinegar can break apart limestone. Fossils made of a different rock do not react with the vinegar.

Separating Metals from Ores

Ores are rocks full of metals and other substances. People may use chemical properties to get the metals from the ores. Iron ore has iron oxide. Heating iron ore in a hot furnace with carbon separates the iron from the oxygen. The products are pure iron and carbon dioxide.

Vinegar reacts with the limestone, not the fossils.

Separating Solutions

Chemical properties can be used to separate elements from solutions. When lead is mixed in a solution with iodine and water, a change takes place. The lead reacts with the iodine to form a yellow solid called lead iodide. You can filter the lead iodide out of the liquid.

Identifying Substances

You can use chemical properties to identify acids and bases. Lemon juice and vinegar are acids. Soaps contain bases. Acids and bases react with chemicals in universal indicator paper. The reactions make the paper change color. Acids turn the paper red. Bases turn the paper purple. Weaker acids or bases turn the paper other colors.

Vinegar **Tap water**

Glossary

chemical change — a change in which one kind of matter changes into a different kind of matter with different properties

chemical equation — a statement of chemical symbols that shows what happens during a chemical reaction

condensation — the process by which particles leave a gas and become a liquid

evaporation — the process by which particles leave a liquid and become a gas

physical change — a change in which matter keeps the same chemical properties; a change in size, shape, volume, or state of matter

product — a substance made by a chemical reaction

reactant — a substance used in a chemical reaction

sublimation — the process by which a solid changes directly into a gas

What did you learn?

1. How do the particles differ in solids, liquids, and gases?
2. Why do materials change size when they change temperature?
3. How are chemical changes related to chemical reactions?
4. **Writing** in Science List and describe three ways that you have used or benefited from chemistry today. After you have written your list, go back and rework it so that it is in time order. Rearrange words and sentences to make the piece clear and interesting.
5. **Draw Conclusions** You boil a raw egg for 10 minutes. You remove the egg from the water, cool it off, and peel it. Did a physical or chemical change take place? Explain.