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Celebrating Chemistry

NATIONAL CHEMISTRY WEEK AMERICAN CHEMICAL SOCIETY

FAST OR SLOW
Chemistry Makes It Go!

NATIONAL CHEMISTRY WEEK

FAST OR SLOW Chemistry Makes It Go!

By Lori R. Stepan

Everything around us is made of **molecules**, including the air we breathe, the objects we touch, and the bodies we use to run, learn, and laugh. Molecules are very small and can't be seen with the naked eye, but they are very important!

Every molecule is made of two or more **atoms**, which are the building blocks of matter, like the individual bricks in a Lego sculpture. Molecules are in constant motion at all times. When they're in a solid phase, they vibrate against each other. When they're in a liquid phase, they slide past each other. And when they're in a gas phase, they are very spread out. **Chemistry** is the study of these atoms and molecules, their properties, and their changes.

Molecules can change into other molecules as they go through **chemical reactions**, which happen when molecules break the **chemical bonds** that hold them together or combine to make new bonds with other molecules, forming new molecules. The starting substances in a reaction are the **reactants**, and the substances produced at the end of a reaction are called **products**. Some chemical reactions are so slow that you can't observe a change right away (such as the formation of rust on a piece of metal), and others are so fast that you might miss them if you blink (like when a firecracker pops).

What kind of things cause chemical reactions? What makes them go fast or slow? To answer these questions, let's think about how chemical reactions are like a certain game you can play at a county fair or carnival.

Imagine you are going to a fair or carnival with a friend, smelling pretzels and cotton candy, hearing music, and watching all the happy people around you. Your friend suggests you try to win a prize at one of the booths by hitting a balloon with a dart, so you give it a go!

What will it take to break the balloon and win the prize? First, you must throw the dart with an excellent aim! Next, your dart must have a **collision** with the balloon. Is *any* collision good enough? No, the dart must have enough force to break the balloon, so you have to throw it hard enough to give it enough **energy**. What about the orientation (or direction) of the dart? If you throw it so that it hits the balloon sideways or on the wrong end, it's unlikely to break the balloon. If you want to win, you have to do everything just right!

Molecules in Motion

A chemical reaction is in some ways similar to the balloon dart game. Molecules are constantly moving and colliding with each other, but they don't always react. In order to have a successful reaction, molecules must have a collision with enough energy to react — this is what's called the **activation energy**. If collision is not "active" enough, the molecules just bounce off each other like balls on a pool table, and go on their way. Finally, they have to be oriented correctly in order to break existing chemical bonds and make new ones. If the wrong ends of the molecules collide with each other, they might not react.

So, molecules are in constant motion, and the right kind of collisions can make new molecules. But what causes a reaction to go fast or slow? Anything that changes how effectively molecules collide will affect the speed of the reaction, which is also called the **reaction rate**. If there are more molecules present, or there's a bigger **surface area** on which the reaction happens, there will be more successful collisions and the reaction will go faster.

Also, if the temperature is higher, more molecules will have enough energy to react, and the reaction will be faster. If the **phase of matter** (solid, liquid, or gas) of the reactants results in more collisions, the reaction will be faster. Gas molecules move fast, so gases usually react faster than liquids. Liquids move faster than solids, so liquids react faster than solids. If a substance called a **catalyst** is present, it can also help a reaction go faster.

In this edition of *Celebrating Chemistry*, you'll find out lots more about the rate of chemical reactions, including how to slow down how quickly sliced apples turn brown, the very fast reactions that happen in cars, the enzymes in your body, what factors affect reaction rates, and more! Celebrate National Chemistry Week 2021 with the theme, "Fast or Slow … Chemistry Makes It Go!"

Lori R. Stepan, Ph.D. *is an Associate Teaching Professor of Chemistry at Penn State University in State College, PA.*

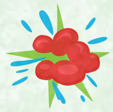
Chemistry Goes Pop!

By Gina Malczewski and David S. Heroux

Introduction of activity

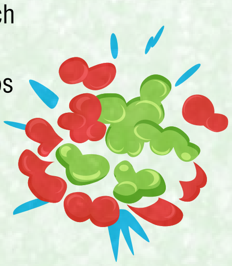
Pop Rocks® is a very special brand of candy — first sold back in 1961! The sugary goodness of the candy coats little pockets of gas that are under pressure. That gas is released when you put the candy in your wet, warm mouth, and the sugar dissolves, allowing you to "taste the explosion!"

You can do an easy experiment with a package of Pop Rocks® to look at the ways temperature affects this process. This experiment also demonstrates how you, as a chemist, can use different ways to measure reactions. In this activity, you can use your eyes, ears, and nose to study how quickly the gas escapes the candy.



Materials

- 2 packs of Pop Rocks®, 0.33 oz (9.4 g) each
- 4 dry bowls or cups of similar size
- Two ½-cup (about 120 mL) measuring cups
- Cold and hot tap water
- Spoon



Procedures

1. Divide one pack of Pop Rocks® candy equally into two bowls that are at least 12 inches (30 cm) apart.
2. Pour ½ cup (120 mL) of cold water into one cup, and ½ cup of hot water into the other.
3. Quickly, and at the same time, pour the water over the Pop Rocks® in the two bowls.
4. Record your observations for each bowl.
5. After the bubbling slows down, stir each with the spoon and observe what happens.
6. Seeing, smelling, and listening are all ways to observe what is happening. If you haven't already done so, try the experiment again with your eyes closed! Focus on what you hear and smell. Be sure to record your observations.

Gina Malczewski, Ph.D. *is a retired biochemist who worked at Dow Corning Corporation in Midland, MI.*

David S. Heroux, Ph.D. *is a Professor of Chemistry at Saint Michael's College in Vermont.*

SAFETY SUGGESTIONS

- Safety glasses suggested.
- Caution: hot liquids!
- Do not eat or drink any of the materials used in this activity.
- Thoroughly wash hands after this activity.
- Don't use extremely hot or extremely cold water.

Disposal: All solutions used in this experiment can be disposed of down the drain with running water. Unused Pop Rocks® can be disposed of in the trash.

Note: Follow Milli's Safety Tips in this issue of *Celebrating Chemistry*.

Observations

Describe what you:
See
Hear
Smell

How does it work?

Pop Rocks® are sugar candies with tiny pressurized bubbles inside them filled with carbon dioxide gas. When you place Pop Rocks® in water, the sugar coating dissolves in water, and the gas and pressure are released. This also makes a popping noise, and leaves behind the sugar molecules.

You might think that a chemical reaction is happening, but this activity investigates a *physical* change, which is when molecules move around, but no new substance is formed. The sugar is dissolved in the water, but it is still sugar. You could find the sugar again if you carefully evaporated the water. Melting, freezing, and boiling are also physical changes.

Sugar crystals are made of many individual sugar **molecules**. Normally, sugar dissolves in water, because the water molecules interact with the individual sugar molecules and make them dissolve. Over time, the crystals seem to disappear, because they become too small to see. However, they are still there in a different form. Hot water has faster-moving molecules and causes the reaction to happen more quickly than cold water would.

Milli's Safety Tips: Safety First!

ALWAYS:

- Ask an adult for permission to do the activity and for help when necessary.
- Read all directions and safety recommendations before starting the activity.
- Wear appropriate personal protective equipment (safety glasses, at a minimum), including during preparation and clean up.
- Tie back long hair and secure loose clothing, such as long sleeves and drawstrings.
- Do not eat or drink food when conducting this activity.
- Clean up and dispose of materials properly when you are finished with the activity.
- Thoroughly wash hands after conducting the activity.

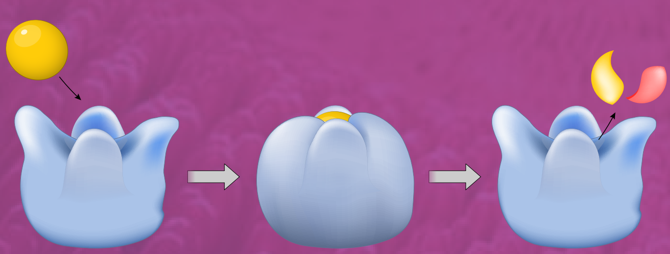
Enzymes: Moving at the Speed of Life

By Keith Michael Krise

All living things depend on millions of chemical reactions that happen constantly. Chemical reactions that keep you alive happen fast! When you eat food, breathe, play, and grow, all of these need chemical reactions, and they must take place quickly.

How does your body speed up these important reactions? The answer is **enzymes**. Enzymes in our bodies are catalysts that speed up reactions by helping to lower the activation energy needed to start a reaction. Each enzyme molecule has a special place called the active site where another molecule, called the substrate, fits. The substrate goes through a chemical reaction and changes into a new molecule called the product — sort of like when a key goes into a lock and the lock opens.

Since most reactions in your body's cells need special enzymes, each cell contains thousands of different enzymes. Enzymes let chemical reactions in the body happen millions of times faster than without the enzyme. Because enzymes are not part of the product, they can be reused again and again. How efficient!



This is an example of an enzyme molecule (blue) and a substrate (yellow). The enzyme and substrate fit together like a lock and key to make the product.

Enzyme activity measures how fast an enzyme can change a substrate into a product. Changes in temperature or acidity can make enzyme reactions go faster or slower. Enzymes work best under certain conditions, and enzyme activity will slow down if conditions are not ideal. For example, your normal body temperature is 98.6°F (37°C), but if you have a fever and your temperature is above 104°F (40°C), some enzymes in your body can stop working, and you could get sick. There are also enzymes in your stomach that speed up the breakdown of the food you eat, but they are only active when they are in your stomach acid. Each enzyme has a set of conditions where they work best, depending on where they act and what they do.

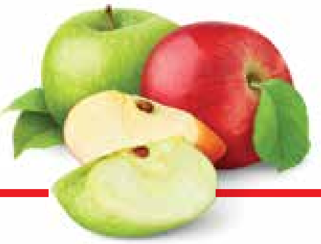
But what happens if an enzyme is missing or doesn't work the way it's supposed to? One example is phenylketonuria (or PKU), a rare inherited disease where the body lacks the enzyme to process proteins. Because of this, toxic molecules can build up, and if they travel to the brain, they may cause severe intellectual disabilities. Infants are all tested for this disease, and if they have it, they need to go on a special diet for life.

Another, less severe, example is lactose intolerance. Many people can digest milk just fine when they are infants or children. But after childhood, many people begin to lose a key enzyme that helps digest milk. If they drink milk, they get terrible stomach pain and diarrhea — all because the enzyme is missing.

Enzymes are important in every living thing. Without them, life as we know it could not, and would not, exist.

Keith Michael Krise, Ph.D. *is an Associate Professor of Chemistry at Gannon University, in Erie, PA.*

Slowing Apple Browning



By David A. Katz and Veronica I. Jaramillo

SAFETY SUGGESTIONS

- Safety glasses suggested.
- Do not eat or drink any of the materials used in this activity.

Disposal: All unused solutions can be poured down the drain with running water. Apple pieces can be composted or disposed of in the trash.

Note: Follow Milli's Safety Tips in this issue of *Celebrating Chemistry*.

Introduction

Have you ever thrown away apple or avocado slices because they started turning brown? Many people find fruit slices with brown spots to be less appetizing. The browning can change the taste and texture of fruit, as well as how it looks. This browning is due to a chemical reaction with oxygen in the air, and it may be responsible for up to half of all food waste. If there were only a way to slow this chemical reaction down, it would prevent a lot of waste … and save a lot of money!

In this activity, you will test different ways of slowing down browning in fruit through chemistry. You'll add different substances to apple slices to discover the most effective way to prevent the slices from turning brown.

Materials

- Apples
- Cutting board
- Plastic knife
- 6 paper plates
- ¼-cup (about 60 mL) measuring cup
- 5 plastic cups
- 5 spoons
- Lemon juice
- Vinegar
- Salt
- Sugar
- Water

Procedures

1. Label 5 plastic cups with these titles: Lemon Juice, Vinegar, Water, Salt Solution, and Sugar Solution.
2. Label 6 paper plates with these titles: Lemon Juice, Vinegar, Water, Salt Solution, Sugar Solution, and No Liquid.
3. Add ¼ cup (60 mL) of water to each of the 3 cups that are labeled Water, Salt Solution, and Sugar Solution.
4. Make the solutions by adding 1 teaspoon (5 mL) of salt and 1 teaspoon of sugar to each labeled cup and stirring with a spoon to dissolve.
5. Pour ¼ cup of lemon juice into the cup labeled Lemon Juice.
6. Pour ¼ cup of vinegar into the cup labeled Vinegar.
7. With the help of an adult, cut the apple into at least 6 uniform slices. Lay one slice on its side on each of the six labeled plates. Use a spoon to dip each of the apple slices into the matching labeled cup for 30 seconds, remove the slice, and then place it on its labeled plate. The apple slice on the plate labeled No Liquid, should not be dipped in any liquid.
8. Check the apple slices at 15-minute intervals for up to one hour. Record your observations in the data table.

What did you observe?

Describe what the apple slices look like. Possible results could include no browning, slight browning, brown patches, halfway light brown, completely light brown, and completely dark brown.

Time (minutes)	No Liquid (control)	Lemon Juice	Vinegar	Water	Salt Solution	Sugar Solution
0						
15						
30						
45						
60						

Look at your data, and compare the browning of your different apple samples to the control apple, which was the slice not dipped in any solution. Which apple browned the least? Which solution was best at slowing down the browning reaction?

How does it work?

An enzyme in apples speeds up the chemical reaction between the fruit tissue and oxygen in the air. When fruits or vegetables are peeled or cut, the enzymes in the plant tissue are exposed to the air. The oxygen in the air speeds up the conversion of some of the nutrients in the apple to a brown product. This browning can be prevented by making the enzyme stop working or slow down.

In your experiment, some of the treatments worked better than others to prevent browning. If they worked, it was because they interfered with the enzyme. Changes in acidity, saltiness, and oxygen content can all affect the enzyme action. Lemon juice and vinegar are quite acidic, and work by altering the pH of the solution. Salt can break up protein structure, which is what enzymes are made of. Sugar solutions can coat the surface of fruits, and prevent oxygen from getting to the surface. Review your results and decide which solution did the best job of slowing down the browning action of the fruit.

Just because something works to prevent browning doesn't mean you want to use it on fruit you plan to eat. Which of the solutions would have the smallest effect on the flavor of your apple slices?

David A. Katz *is a Consultant of Chemistry Education in Wilmington, DE.*
Veronica I. Jaramillo, Ph.D. *is the Department Chair of Physical Science at Pasadena City College in Pasadena, CA.*

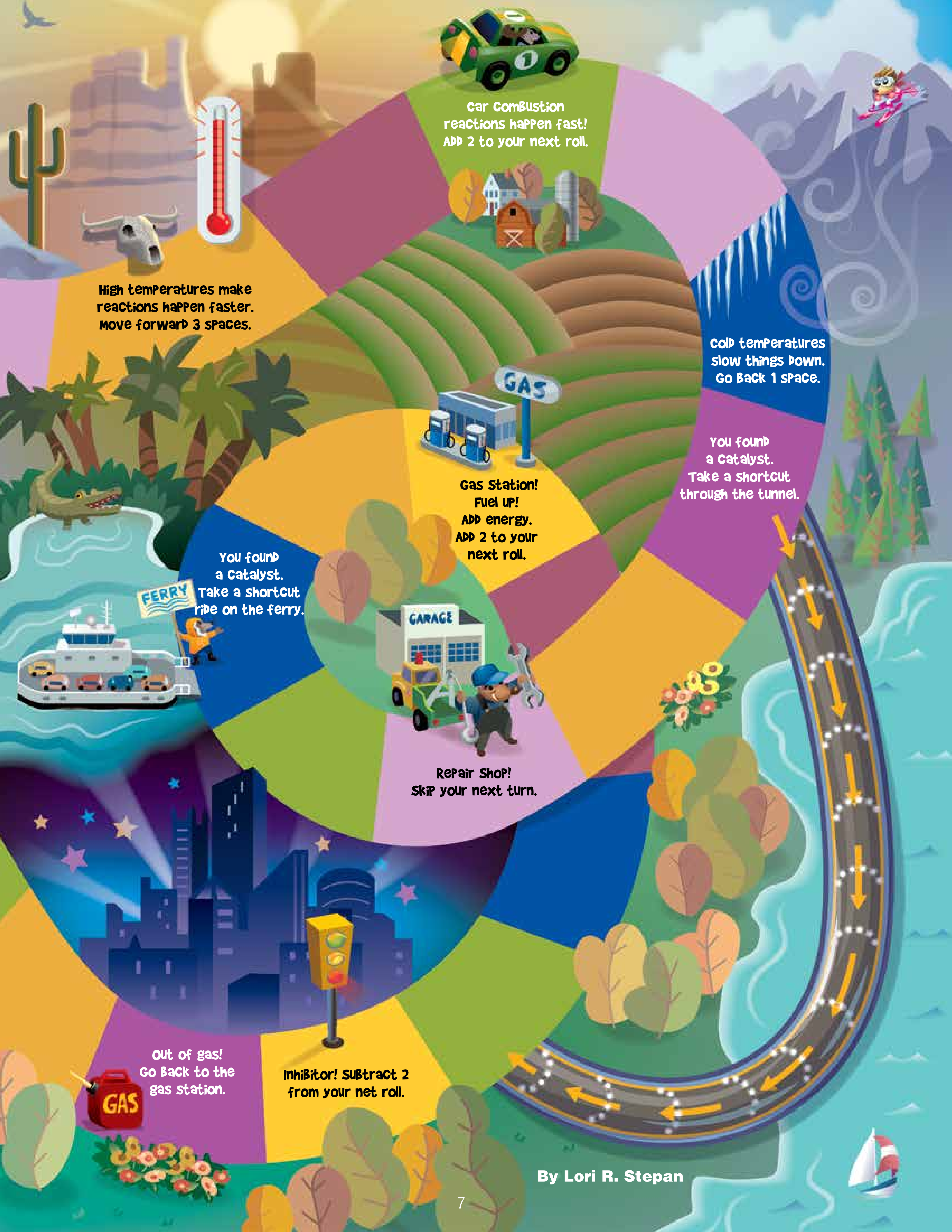
THE GREAT REACTION RACE!

You Will Need

- 2–4 Players
- Six-Sided Die (or Digital simulator!)
- The game Board on this Page

Game Directions

1. Each Player Picks a Different Coin or small object to use as a game Piece, and Places it on the starting line.
2. Each Player rolls the Die, and the Player with the highest roll goes first.
3. On each Player's turn, they roll the Die, and move forward the number of spaces shown on the Die. If a Player lands on a space that contains instructions, the Player must follow them.
4. The first Player to cross the finish line wins the Great Reaction Race!



By Lori R. Stepan

Need Clean Air, Quick?

Catalytic Converters to the Rescue!

By William J. Doria

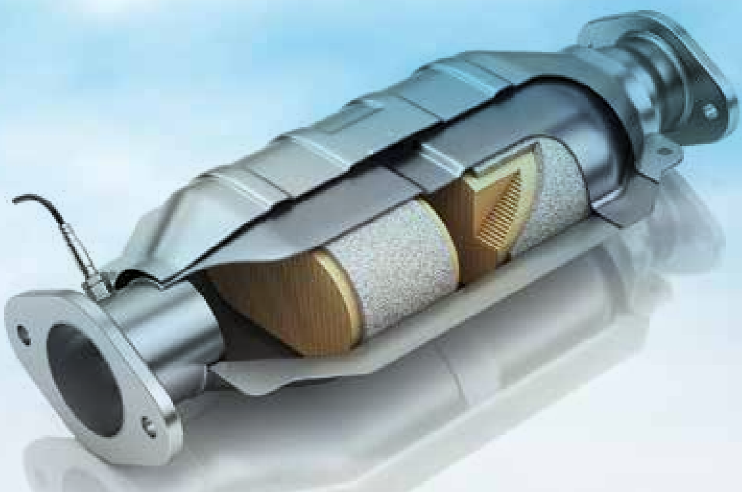
It's hard to imagine living without cars or trucks! They help us to travel long distances quickly and easily, and also to send and receive deliveries. But unfortunately, there are problems with how much we depend on cars and trucks. One big problem is that the gasoline and diesel they use creates exhaust, which contains many different gases that pollute our air and water. The pollution can lead to very unhealthy air and, over decades, can even cause climate change. What makes the exhaust so bad for us, and how can we improve it?

One of the gases in exhaust is called carbon monoxide (CO), which is a poisonous gas that's fatal to breathe in large amounts. Other gases in car exhaust are called hydrocarbons (because they're made up of atoms of hydrogen and carbon), and they can contribute to climate change. Two other ingredients in exhaust are nitric oxide (NO) and nitrogen dioxide (NO_2), which lead to acid rain. Acid rain damages the trees in forests, and makes the water unhealthy for fish and plants that live in ponds, lakes, and streams.

That all sounds pretty bad – so how can we solve the problem of automobile pollution? That's where chemists come in! All those polluting molecules eventually break down and form other molecules that aren't as bad for the environment. But those chemical reactions take a long time, so chemists use what's called a catalyst. A **catalyst** is a substance that helps a chemical reaction happen faster.

You've probably seen the results of catalysts without even realizing it! For example, do you like bread, cheese, or yogurt? In order to make these types of food, we need to perform a chemical reaction called fermentation. Fermentation is usually too slow to use in cooking, so we add a catalyst to speed up the reaction! For bread, that catalyst is in the yeast we add to bread dough.

Chemists have learned how to use catalysts to speed up the reactions that break down car exhaust. If your family's car runs on gasoline, it has a device called a **catalytic converter**. Inside this device is the catalyst, which is a piece of metal — usually platinum, palladium, or rhodium. These metals are valuable. The metal is coated onto a ceramic mesh that looks kind of like a screen you might have in your windows at home.



Oxygen and carbon monoxide stick to the surface of the platinum catalyst. That helps the molecules get close enough to react quickly with each other to form carbon dioxide.

When a car's exhaust goes through the mesh, pollutant molecules stick to the metal. When these molecules get stuck to the metal, some of their chemical bonds are weakened and it becomes easier for them to have effective collisions with other molecules. As a result, they quickly undergo chemical reactions that turn them into less harmful gases. For example, carbon monoxide (CO) and oxygen (O_2) combine to form carbon dioxide (CO_2), which isn't as dangerous as carbon monoxide. And because the metal is a catalyst, the reaction happens much more quickly than it would without the catalytic converter.

The screen inside a catalytic converter is coated with platinum. That's the catalyst!

Catalytic converters work really well! A brand-new one catches about 99% of the pollutants mentioned above, and converts them into safer chemicals. Thanks to catalysts in your car, we can all breathe a lot easier!

William J. Doria, Ph.D. *is an Assistant Professor of Chemistry at Rockford University in Rockford, IL.*

That's One Fast Reaction!

By Lori R. Stepan

Did you know that a really fast chemical reaction makes riding in a car safer? Most cars have airbags built into the dashboard and steering wheel that can blow up like super-fast balloons during a collision, and cushion riders from getting hurt. What makes the airbag blow up like a balloon? Chemistry! Instead of transporting compressed gas in the car to inflate the airbag, we take advantage of a very fast reaction that produces the needed gas.

Many car airbag inflators contain small amounts of a toxic molecule called sodium azide, or NaN_3 (one sodium atom and three nitrogen atoms combined). Sodium azide breaks down very quickly when heated or physically shocked. This is called decomposition. The products of the **decomposition** are sodium atoms and nitrogen gas.

If the car is involved in a collision, sensors send an electric signal to the container where the sodium azide is located. The signal ignites a flammable compound, and the **heat** it creates starts the decomposition of the sodium azide.

A huge amount of nitrogen gas immediately rushes out with an explosion and fills the airbag. It is amazing that from the time the sensor detects the collision to the time the airbag is fully inflated is only 30 milliseconds, or three one-hundredths of a second! A normal blink of your eye is 100 milliseconds. Around 50 milliseconds after a collision, the person riding in the car hits the air bag, which absorbs their forward-moving energy and protects them from slamming into other parts of the car. Chemistry has saved the day!

A relatively small amount of sodium azide (4.6 ounces or 130 g) will produce a lot of nitrogen gas very quickly; it takes almost five party balloons' worth of gas to fill a normal air bag! This sodium metal product can be a potential hazard, but in this case, other ingredients react with the sodium to form safe compounds.

You may be able to think of other situations where fast production of a gas is needed. For example, sodium azide is also used to inflate airplane escape chutes in case of an accident. If you were an inventor, how would you use this fast production of gas?

Lori R. Stepan, Ph.D. *is an Associate Teaching Professor of Chemistry at Penn State University in State College, PA.*

The Adventures of Meg A. Mole, Future Chemist

Dr. Francisco Zaera

In honor of this year's National Chemistry Week theme, "Fast or Slow…Chemistry Makes It Go!", I traveled to the University of California, Riverside, to learn more about chemical reaction rates. When I think of a chemical reaction, I immediately think of what happens when you mix vinegar and baking soda together – it's a fun reaction to watch, but messy! I could not wait to learn more about chemical reaction rates from my new friend, Dr. Francisco Zaera, Distinguished Professor of Chemistry!

Dr. Zarea showed me his office, and the laboratory where his graduate students and postdocs do their experiments. "I work with catalytic systems, and catalysis is all around us. A lot of industrial processes use catalysts to accelerate reactions, and catalysis is also used to remove pollutants from the environment," he explained. When I asked how he did that, he replied, "I look into how reactions take place on solid surfaces, and how that relates to catalytic processes and to the creation of thin solid films (which are used for making microelectronics)."

One of the projects he worked on recently helped in the exploration of another planet! "I was recently an advisor for the NASA Jet Propulsion Laboratory, was responsible for deciding to use titanium nitride as the coating material of the tubes used to collect samples in the Mars 2020 mission," he said. How exciting to be able to do chemistry that is used on Earth and other planets!

Growing up, Dr. Zaera's favorite subjects were math and science. He explained that he decided to go into a science career because he had a "curiosity to know how things worked." His father also encouraged him to do science experiments and projects. "My initial interest was in math," he told me, "but then I entered a contest in high school to show how to design circuits where light can be turned on and off from several switches."

I asked Dr. Zaera what he liked the most about his job. "The freedom to ask questions and try to answer them, and the chance to train others in science," he said. The best thing about being a scientist is that it "is a way of life, a state of mind," said Dr. Zaera. I am so thankful for scientists like Dr. Zaera. They remind you that chemistry is not only down to earth, but out of this world!

Personal Profile

Favorite food? Plaintains

Favorite pastime/hobby? I like to travel and explore other cultures.

Very interesting project you were a part of? The 2020 mission to Mars

Word Search

Try to find the words listed below — they can be horizontal, vertical, or diagonal, and read either forward or backward.

M	L	J	Q	Y	E	T	E	N	E	R	G	Y	N	N
O	C	O	N	Z	K	H	G	A	H	H	U	O	A	O
L	O	W	A	D	J	Y	Q	M	N	U	I	L	E	I
E	E	T	N	A	T	C	A	E	R	T	M	G	R	S
C	J	T	X	P	A	S	W	R	I	Y	O	D	A	I
U	V	P	A	T	T	O	Y	S	Q	D	J	C	E	L
L	Y	Z	N	R	D	L	O	L	I	H	Q	H	C	L
E	M	G	I	O	N	P	E	P	A	K	K	W	A	O
Y	Y	C	H	M	M	O	R	N	M	T	H	F	F	C
F	M	R	T	O	Z	O	I	H	Z	B	A	A	R	S
P	B	M	C	E	D	E	M	T	D	Y	X	C	U	Q
S	Q	E	I	U	L	U	J	B	C	Y	M	M	S	Z
J	D	R	C	Y	Y	W	M	V	M	A	Z	E	D	T
B	S	T	X	I	L	J	O	M	B	M	E	C	U	B
C	W	Q	C	L	X	Z	D	E	J	X	G	R	C	P

CATALYST	DECOMPOSITION	MOLECULE	REACTION RATE
COLLISION	ENERGY	PRODUCT	SURFACE AREA
	ENZYME	REACTANT	

For answers to the word search, please visit **www.acs.org/celebratingchemistry**.

Slow the Glow

By David A. Katz

SAFETY SUGGESTIONS

- Safety glasses suggested.
- Caution: hot liquids!
- Use an insulated oven mitt or potholder to hold container of hot water.
- Use kitchen tongs to remove light stick from hot water.
- To avoid contact with the chemicals, do not cut open the light sticks.

Disposal: At the conclusion of all observations, the light sticks can be disposed of in the regular household trash.

Note: Follow Milli's Safety Tips in this issue of *Celebrating Chemistry*.

Introduction

Chemical light sticks (also called glow sticks) are a lot of fun. You may have used them for Halloween, or maybe at a birthday party. They produce a cool, soft light that is unlike most other lights, and it's too bad that they don't last forever! The glow of a light stick comes from a chemical reaction, and this phenomenon is called chemiluminescence.

It may be difficult to tell, but there are a couple of different chemical compounds in the stick. One is kept inside of a glass tube, while others are outside of it. All of this is sealed inside of a plastic tube that is safe to hold. When you break the glass tube inside by bending the stick, the chemicals mix, react, and glow! Do you know how to slow the glow so that the light lasts longer? This activity holds the key.

Materials

- 3 light sticks (Cyalume or generic glow sticks)
- 3 tall clear plastic or glass cups that are taller than the light sticks
- Kitchen tongs
- Oven mitt or potholder
- Cold water made by placing several ice cubes in water
- Hot tap water (do not use water that is hotter than 120°F, or about 50°C)

Procedures

1. Fill one clear cup with ice water and another with hot water. Fill each to a level that will mostly cover the light stick. Be sure to use an oven mitt or potholder to handle the cup of hot water.
2. Bend three light sticks. Listen closely! You might be able to hear the glass tube inside of the light stick breaking. Shake each light stick to help the chemicals mix.
3. At the same time, place one light stick in the cold water, and another one in the hot water. Place the final one in the empty cup as a control.
4. Wait several minutes. If necessary, wipe the outside of each cup with a towel so you can clearly see the light sticks. Compare the brightness of the light sticks in cold water and hot water to the control light stick at room temperature. Add ice cubes to the cold water as needed.
5. If time allows, observe the light sticks several times over the course of one day. Make sure the cold water stays cold by adding ice. Determine how long each light continues to glow.

What did you observe?

- How does the intensity of the light in the light sticks change after several minutes in the hot and cold water?
- If you do a long-term observation of the light sticks for many hours, how long does each of the light sticks continue to give off light?

***David A. Katz** is a Consultant of Chemistry Education in Wilmington, DE.*

How does it work?

A light stick contains more than one chemical. One solution is a phenyl oxalate ester and a fluorescent dye. Inside the glass tube is a solution of hydrogen peroxide. When you bend the light stick, the glass tube breaks, which causes the solutions to mix and chemically react. The energy of the reaction is transferred to the dye, which produces the light. The intensity of the light is related to the reaction rate.

By changing the temperature, you can slow down or speed up the reaction. Did you notice that the glow is dimmer from the light stick in the cold water than in the hot water? The reaction in the light stick in the cold water is happening more slowly, because the cold temperature slows down the molecules of the chemicals inside the light stick. That causes them to collide less, and react more slowly.

Light sticks will continue to glow as long as the chemical reaction is happening. Eventually all light sticks get to a point when they no longer produce light. This is because the chemicals were used up in the chemical reaction. When the chemical reaction inside a light stick ends, it stops glowing. If you observed the light sticks over a few hours, after a while the light stick in the hot water becomes dimmer than the light stick in the cold water. This is because all of the chemicals have been used up in the faster reaction of the light stick in the hot water.

Now your challenge is to see if you can apply what you've learned to make your light sticks last as long as they can! (Hint: think of a cold place you have in your home!)

Words to Know

Activation energy – the minimum amount of energy needed for a chemical reaction to proceed.

Atom – the smallest unit of a chemical element that has the characteristics of the element.

Catalyst – a substance that helps a chemical reaction go faster, but does not undergo any permanent chemical change itself.

Catalytic converter – a device in gasoline-powered cars that catches pollutants in a car's exhaust and changes them to less harmful substances.

Chemical bond – forces of attraction between atoms or molecules that create compounds.

Chemical reaction – the process of rearranging atoms between substances to make different substances.

Chemistry – the study of matter, its properties, and its changes.

Collision – when a moving object strikes against another object; in chemistry, the objects are atoms and molecules.

Decomposition – a type of chemical reaction in which a substance breaks down into simpler parts.

Element – a pure substance, such as copper or oxygen, made from a single type of atom. Elements are the basic building blocks of all matter.

Energy – what makes things change and move. All changes are caused by energy, and there are many types, including wind, chemical, or electrical energy.

Enzyme – a molecule in living things that acts as a catalyst.

Heat – a form of energy created by the vibration of atoms and molecules.

Molecule – the smallest unit of a chemical compound. They are made from two or more atoms.

Phase of matter – describes whether a substance is solid, liquid, or gas.

Product – a substance produced at the end of a chemical reaction.

Reactant – a substance that is part of a chemical reaction and is changed by it.

Reaction rate – the rate at which a chemical reaction proceeds.

Surface area – the amount of space covering the outside of an object.

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The American Chemical Society (ACS) is one of the world's largest scientific organizations. ACS members are chemists, chemical engineers, and other professionals who work in chemistry or chemistry-related jobs. The ACS has over 152,000 members in more than 130 countries around the world. Members of the ACS share ideas with each other and learn about important discoveries in chemistry during scientific meetings held several times a year, through the ACS website, and through the many peer-reviewed scientific journals the ACS publishes. ACS members carry out many programs that help the public learn about chemistry. One of these programs is National Chemistry Week, held annually during the third week of October. ACS members celebrate by holding events in schools, shopping malls, science museums, libraries, and even virtually online! Activities at these events include carrying out chemistry investigations and participating in contests and games. If you'd like more information about these programs, please contact us at **outreach@acs.org.**

About Celebrating Chemistry

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The activities described in this publication are intended for children under the direct supervision of adults. The American Chemical Society cannot be responsible for any accidents or injuries that may result from conducting the activities without proper supervision, from not specifically following directions, or from ignoring the cautions contained in the text.

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