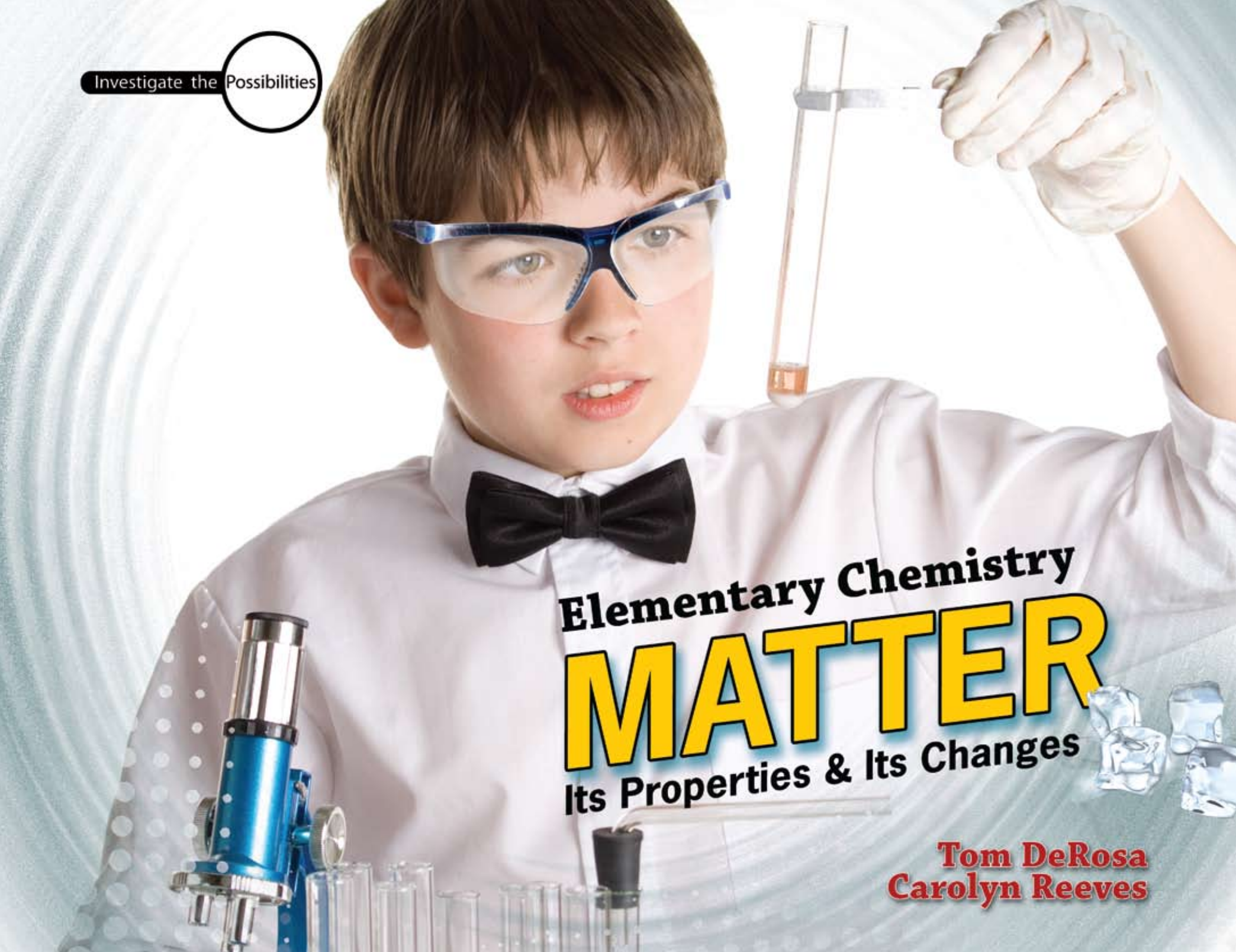
Investigate the Possibilities
Elementary Chemistry
MATTER
Its Properties & Its Changes
Tom DeRosa
Carolyn Reeves

Elementary Chemistry

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About the Authors

Tom DeRosa, as an experienced science educator and a committed creationist, has incorporated both his passions in the founding and the directing of the Creation Studies Institute, a growing national creation organization whose chief focus is education. His wealth of experience in the public school classroom, Christian school, and the homeschool markets for over 35 years has given special insights into what really works in engaging young minds. He holds a masters degree in education, with the emphasis of science curriculum. He is an author and sought-out, enthusiastic creation speaker who has a genuine love for the education of our next generation.

Carolyn Reeves is especially skilled at creating ways to help students develop a greater understanding of not just scientific concepts, but also how these are applied within the world around us. Carolyn retired after a 30-year career as a science teacher, finished a doctoral degree in science education, and began a new venture as a writer and an educational consultant. She and her husband make their home in Oxford, MS, where they are active members of North Oxford Baptist Church. The Reeves have three children, three in-law children, and ten grandchildren.

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INTRODUCTION

In this book, we will be studying matter, its properties, its changes, and its interactions. The investigations will include things you can observe or measure. However, much that is going on will involve tiny particles you cannot observe. Have you ever wondered how scientists know so much about things they cannot see?

You will come to appreciate the creativity of the early scientists who were able to understand so many things about matter. Many of these scientists had full-time jobs and did their research in their spare time.

Sometimes early scientists had to undo wrong ideas. One ancient theory stated that there were only four basic elements — water, air, earth, and fire. It was wrong, of course, but it was an idea that stayed around for almost 2,000 years.

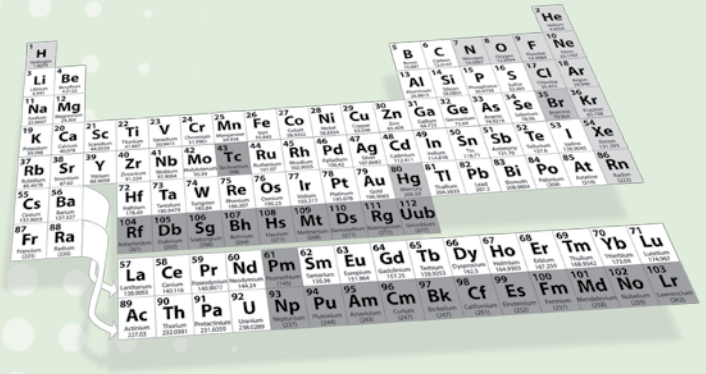
Some of the first chemists were known as alchemists. They thought they could make gold out of lead and other substances. They were also wrong, but scientists still learned some important ideas about science through them.

The science of chemistry came about in spite of false starts and mistakes. There were times when scientists made important discoveries, but didn't realize they had done so. There were frequent times when scientists vigorously disagreed with each other about their explanations and interpretations.

New knowledge emerged at a slow pace, with clues coming from many scientists. They started with things they could observe. They learned more about the properties of substances and how they changed under different conditions. They gradually came to realize that matter is made up of tiny particles too small to be seen.

New technologies have led to even more amazing discoveries about the chemical substances around us. There is still much to learn and understand about the invisible world of atoms and molecules in the future. Perhaps future chemists will help solve some of the world's big problems by producing alternative fuels, food sources, building materials, or medicines.

You may be surprised to learn that a large number of the early chemists were dedicated Christians who considered their research a way to bring glory to God the Creator. One of the Christian chemists from the 1600s (Robert Boyle) wrote, "When . . . I study the book of nature I find myself oftentimes reduced to exclaim with the Psalmist, How manifold are Thy works, O Lord! In wisdom hast Thou made them all!" We hope that you too will recognize the great wisdom of our Creator as you investigate the world of matter.



Scientists

From 1600s:	Robert Boyle	(1627–1691)
From late 1700s:	Henry Cavendish	(1731–1810)
	Antoine Lavoisier	(1743–1794)
	Joseph Priestley	(1733–1804)
From early 1800s:	John Dalton	(1766–1844)
From late 1800s:	Dmitri Mendeleev	(1834–1907)
From early 1900s:	William Thomson (Lord Kelvin)	(1871–1937)

HOW TO USE THIS BOOK

Each investigation gives students a chance to learn more about some part of God's creation. To get the most out of this book, students should do each section in order. Many science educators believe science is best learned when students begin with an investigation that raises questions about why or how things happen, rather than beginning with the explanation. The learning progression recommended for this book is: engage, investigate, explain, apply, expand, and assess. In each lesson, students will be introduced to something that is interesting, they will do an investigation, they will find a scientific explanation for what happened, they will be able to apply this knowledge to other situations and ideas, they will have opportunities to expand what they learned, and there will be multiple assessments.

Think about This – (Engage) Students should make a note of what they know or have experienced about the topic. If this is a new topic, they could write some questions about what they would like to learn.

The Investigative Problem(s) – Students should be sure to read this so they will know what to be looking for during the investigation.

Gather These Things – Having everything ready before starting the investigation will help students be more organized and ready to begin.

Procedures and Observations – (Investigate) Students should first follow the instructions given and make observations of what happens. There will usually be opportunities for students to be more creative later.

The Science Stuff – (Explain) This section will help students understand the science behind what they observed in the investigation. The explanations will make more sense if they do the investigation first.

Making Connections – (Apply) Knowledge becomes more permanent and meaningful when it is related to other situations and ideas.

Dig Deeper – (Expand) This is an opportunity for students to expand what they have learned. Since different students will have different interests, having choices in topics and learning styles is very motivating. All students should aim to complete one "Dig Deeper" project each week, but the teacher may want older students to do more. Generally, students will do at least one project from each lesson, but this is not essential. It is all right for students to do more than one project from one lesson and none from another.

What Did You Learn? – (Assessment) The questions, the investigations, and the projects are all different types of assessments. For "What Did You Learn?" questions, students should first look for answers on their own, but they should be sure to correct answers that might not be accurate.

The Stumpers Corner – Students should ask classmates (or others) two original short-answer questions about what they have learned in this lesson, noting if the questions stumped anyone or not. Write the questions and answers in the Student Answer Book. Another option is to write two questions they would like to learn more about.

Additional opportunities for creative projects and contests are found throughout the book. For grading purposes, they can be counted as extra credit or like a "Dig Deeper" project.

Nurture Wisdom and Expression

Each book contains information about early scientists and engineers. Students need to see that they were regular people who had personal dreams and who struggled with problems that came into their lives. Students may be surprised to realize how many of the early scientists believed that understanding the natural world gave glory to God and showed His wisdom and power.

In addition to the science part, students will find creation apologetics and Bible mini-lessons. The apologetics will clear up many of the misconceptions students have about what science is and how it works. Both the apologetics and Bible lessons should lead to worthwhile discussions that will help students as they form their personal worldviews.

Students with artistic and other creative interests will have opportunities to express themselves. For example, some of the apologetics are written in narrative form and are suitable for drama presentations. As scientists are introduced and researched, students can also present what they have learned as time-dated interviews or news accounts. Remember, if the scientists are included in a drama presentation, they should be represented as professionals, not as stereotyped, weird-looking people.

The Physical Side of Chemicals

Think about This

A detective collected samples of food from the table where a victim was eating when he collapsed. The detective sent them to a crime lab. A few days later, the lab called to say they had positively identified a poison in the victim's food that was not in anyone else's food. Have you ever wondered how someone in the crime lab could figure out what chemicals are present in food or in someone's blood or in something else?

The Investigative Problems

How can the physical properties of a chemical substance be used to help identify the substance?

Procedure & Observations

Your teacher will show you ten items. Your job is to identify one of the items on the basis of its physical properties. You should eliminate any item that doesn't match the descriptions. These are the physical properties of the item: It is round. It is flat. You would not want to eat it. It would be hard to break. It is shiny. What is the item that has all of these properties?

Your teacher will give you some more substances to investigate, but each of these will be a pure chemical substance. They will be either an element or a compound.

Bring a magnet near each substance and observe if the magnet has an effect on it. Place each substance in a container of water and observe if it floats or sinks. Note if it is soluble (will dissolve) or insoluble (will not dissolve) in the water. Note also the color and whether it is shiny or dull. Put this information in a data table.

Substance	Effect of a magnet	Float or sink in water	Soluble or insoluble in water	Color	Shiny or dull
Iron nail					
Paraffin					
Sugar cube					
Oil					
Copper penny					

Use your chart to identify each substance.

1. Which substance is attracted to a magnet?
2. Which substance is a shiny orange-brown color and sinks in water?
3. Which substance is soluble (dissolves) in water?
4. Which substance is a solid and floats on water?
5. Which substance is not a solid and floats on water?

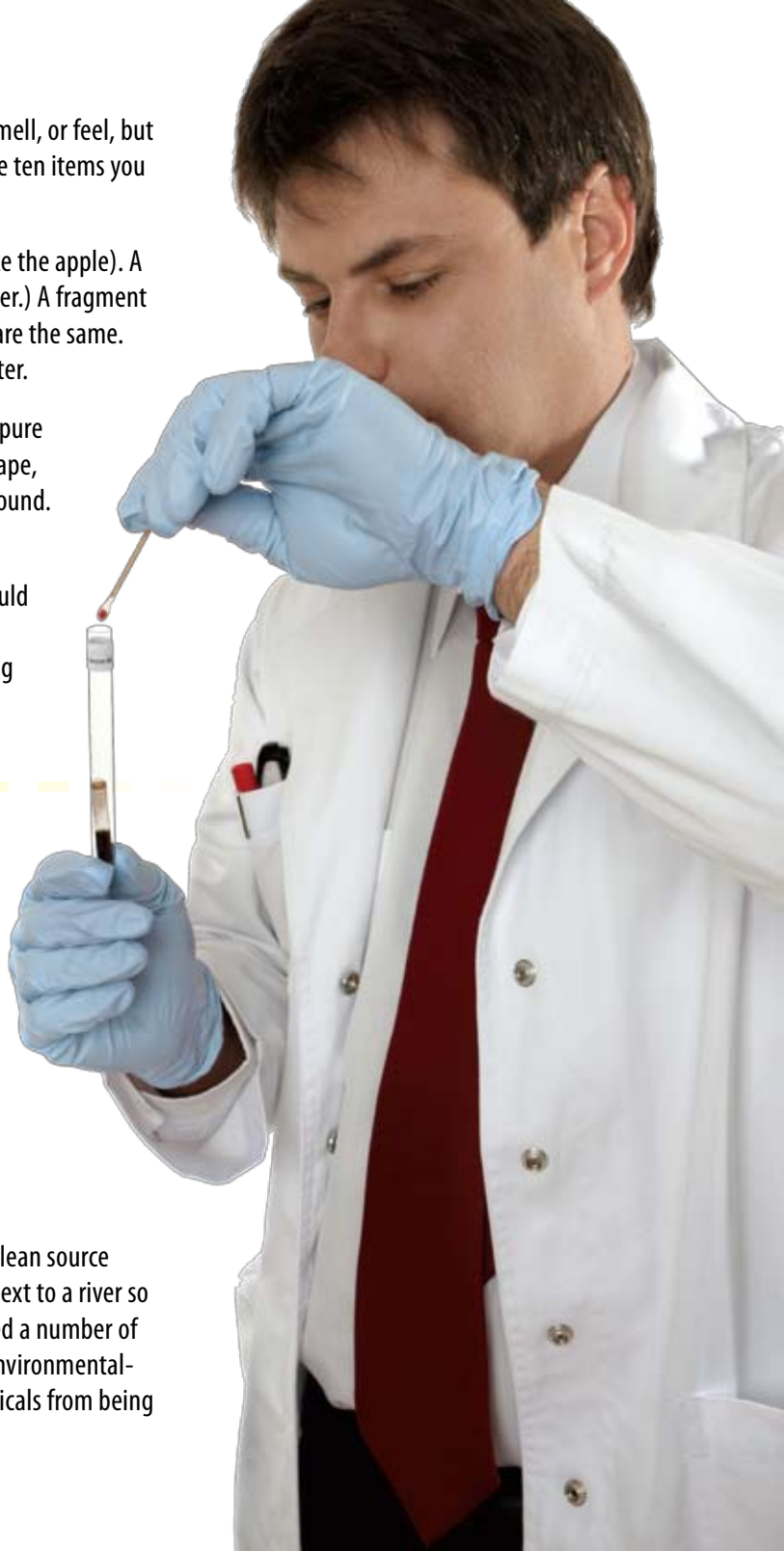
The Science Stuff

Physical properties are often characteristics you can see, hear, taste, smell, or feel, but may include any physical characteristics of a substance. You used some simple physical characteristics to identify one of the ten items you were first shown.

Some of the items you were shown were pure substances (like the glass) and some were a mixture of many substances (like the apple). A pure chemical substance could be either an element or a compound. (We'll learn more about elements and compounds later.) A fragment of a pure substance would have the same properties as the whole substance. All of the basic particles in a pure substance are the same. For example, a piece of pure iron only contains particles of iron and a container of pure water only contains particles of water.

Properties such as size and shape were helpful in identifying the first items, but they are seldom considered in identifying pure chemical substances. The properties of the five pure substances listed in the chart will be present regardless of the size, shape, or amount of the substance. Scientists look for characteristics that will remain the same no matter where the chemical is found. Almost any substance can be made into a round shape, so this would not be helpful in knowing what chemical is present.

We examined physical properties of several pure substances, including the effects of a magnet, whether the substance would float or sink in water, whether the substance was soluble or insoluble in water, its color, and its shininess. There are many other properties we could have considered, such as odor, taste, density, hardness, brittleness, elasticity, melting and boiling temperatures, solubility in other liquids, conductivity of heat and electricity, and viscosity.



Making Connections

There is a huge need for methods, instruments, and trained people to identify chemical substances that are present in things. Identifying unknown chemicals is part of the study of analytical chemistry. This includes what chemicals are present, their characteristics, and how much is present. There are many crime labs that hire people to help solve crimes by identifying such things as drugs, alcohol, poisons, or traces of gunpowder. Medical labs test blood and urine for the presence of many kinds of substances. Other labs help identify pollutants in the air, water, and environment. Industries must constantly monitor their products for impurities. These are only a few of the places where chemicals are analyzed.

One of the most important things any society can do is to maintain a clean source of water. During the Industrial Revolution, many factories were built next to a river so they could dump their wastes into the river. Congress eventually passed a number of laws to try and keep our water sources free of pollution. Even today, environmentalists look for better ways to prevent pesticides and other harmful chemicals from being washed into rivers and lakes after a rain.

Dig Deeper

Labs generally use both traditional methods and a variety of instruments to identify chemical substances. An instrument known as a spectroscope is often used to help analyze the chemicals in something. Do some reading about spectroscopes to find out how they work and what uses they have.

Crime labs often hire forensic scientists. What do forensic scientists do? Is there more than one kind of forensic scientist? If so, what are the different areas in which they work?

What are some of the U.S. laws that try to prevent water pollution? Do all countries have similar laws? Try to find the name of one charity whose mission is to provide clean water to people who don't have clean water to drink.

What Did You Learn?

1. What are physical properties of chemical substances?
2. When scientists want to know what chemical substances are in an item, they seldom consider the size, shape, and amount of the item. Why is that?
3. Give ten examples of physical properties used by scientists to describe a chemical substance.
4. What is a pure chemical substance?
5. What are some of the things students learn about in analytical chemistry?
6. What are some of the main things that are done in medical labs?
7. How might an environmental agency use a lab that analyzes chemical substances?
8. Are the physical properties of a piece of pure iron the same anywhere pure iron is found?

Strange Substances and Their Properties

Think about This

Marita challenged her friends to guess what she had inside a plastic container. She called it MX for, Marita's unknown chemical. It moved around the bag like a liquid, but when someone squeezed it, part of it became hard like a solid. Marita asked if she could pour it into a bowl and show everyone some more properties. Her teacher agreed and said she was going to show them another really strange substance that is found in baby diapers.

The Investigative Problems

What are the physical properties of MX and the chemical in baby diapers?

Procedure & Observations

Part I.

1. Your teacher will give you some MX in a zip bag. Look at the MX mixture through a clear zip plastic bag. Hold the bag by the different corners. Does it have properties of a liquid?
2. Hit the bag of MX (not too hard). Does it feel like a solid?
3. Pour the contents of the bag into a plastic bowl. Pick up some MX in a spoon and let it fall back into the bowl. Does the substance act like a liquid or a solid as it falls? Describe how it falls.
4. Now slowly push your finger into the MX until your finger is touching the bottom of the pan. Pull your finger out slowly. What happened?
5. Slowly push your finger into the MX again. When it is touching the bottom of the pan, try to pull your hand out quickly. What happened?
6. Now try to quickly jab the surface of the MX with your fingers. What happened?
7. Try pushing the back of a spoon through a container of MX. Move the spoon as fast as you can. Describe what happens. Now move the spoon through the MX very slowly. Is there a difference in how hard it is to push the spoon?

Part II.

1. You will need two people to do this activity. Hold a baby diaper over a pan or sink and pour 50 mL of warm water into the inside center of the diaper. Predict how much warm water you think the diaper can hold before it begins leaking. Add another 50 mL of warm water and tilt the diaper back and forth so the water can be exposed to dry areas. Continue to add 50 mL of warm water until the diaper can no longer hold any more water and it steadily leaks. Record the total amount of water you added before it began to leak. Set the diaper aside to examine later.
2. Take another diaper and separate the outer and inner lining from the middle layer. Throw away the outer stuffing and all the linings. Tear the middle layer of the diaper into small pieces. Measure the volume of these pieces of the diaper in a dry graduated cylinder or measuring cup, and record this amount. Put the pieces of the middle layer of the diaper into a gallon plastic zip bag. Add 50 mL of warm water to the bag. What do you see?
3. Continue to add 50 mL of warm water to the bag until the bag is full or the water separates from the diaper material. Keep up with the total amount of water you added.
4. Place the first diaper in a plastic bowl and pull it apart. Compare the inner contents of this diaper to the material in the gallon zip bag.
5. Estimate how much water was added for every 100 mL of dry diaper material. This doesn't need to be exact — just an estimate.
6. List some of the physical properties of the substance in the baby diaper that you observed.

The Science Stuff

MX is actually a mixture of cornstarch and water, but it acquires its own set of interesting physical properties. At times it has properties of a liquid and other times it has properties more like a solid. The water can move in and out of the cornstarch. If you press your fingers into it quickly, the water and cornstarch remains firmly in place. If you press it slowly, the mixture is very fluid. Once your fingers are in the mixture, you will have no trouble removing them slowly. It will be hard to remove them quickly.

The viscosity of MX changes under different conditions. Viscosity is a property of liquids that is related to how slowly they pour from a container or how hard it is to push something through the liquid. Molasses, for example, has a high viscosity because it pours slowly. If it is difficult to push an object through a liquid, the liquid is also said to have a high viscosity. You should have noted that you could push the spoon through the mixture slowly, but it was much more difficult to push it quickly.

Many liquids become less viscous (have less viscosity) when the temperature increases. MX may change viscosity as you apply pressure.

The chemical you separated from the baby diaper is a superabsorbent man-made polymer. It has the unusual property of being able to soak up hundreds of times its weight in water. This kind of polymer is made when many similar small chemicals (called monomers) join together to form long chains of molecules. It is similar to cotton, which is a natural polymer.

Making Connections

Having the proper viscosity is important in choosing motor oils to lubricate cars and trucks. Summer-weight and winter-weight oils allow for changes in summer and winter temperatures. Winter-weight oils are less viscous in cold weather. Summer-weight oils are more viscous in hot weather.

Temperatures reach -40° to –60° F in some places in Alaska during the winter. At these temperatures, residents must use very thin and runny motor oil (low viscosity). They must also keep a heater in the oil pan when vehicles are not in use to keep the oil warm.

The addition of water-absorbing polymers is the secret for no-leak baby diapers. Water-absorbing crystals have other exciting uses. For example, they can be placed in the soil when they are full of water (hydrated), and they will slowly release water to plant roots over a long period of time.

Dig Deeper

Talk with someone who works in a car shop that changes oil in cars. Find out more about the differences in summer-weight and winter-weight oils and why they need to be different.

Talk with someone who has lived in Alaska or another area that has long periods of freezing weather. Find out more about how they were able to keep their cars running during those very cold months.

Not too many years ago, baby diapers were made of cloth and were reusable. Today, most American parents use disposable diapers for their babies. Some environmentalists fear that these disposable diapers are creating an environmental problem. Do some research to see why they are concerned about disposable diapers.

Do an experiment by planting two groups of radish seeds. Purchase some water-absorbing polymer crystals from a lawn and garden center. (Commercial products are available under several trade names.) Let the crystals absorb a large amount of water, mix them with an equal amount of moist soil, and plant ten radish seeds in this mixture. Plant ten radish seeds in soil that does not contain the hydrated crystals. Do not water either group. For two weeks, keep a daily record of how the plants are growing.

What Did You Learn?

1. Give several physical properties of MX.
2. There are several ways to describe viscosity. Find two or more ways to describe viscosity.
3. Viscosity of oils and molasses is often affected by temperature. What affects the viscosity of MX?
4. What is one unusual property of the chemical we tested in the baby diaper?
5. What are polymers?