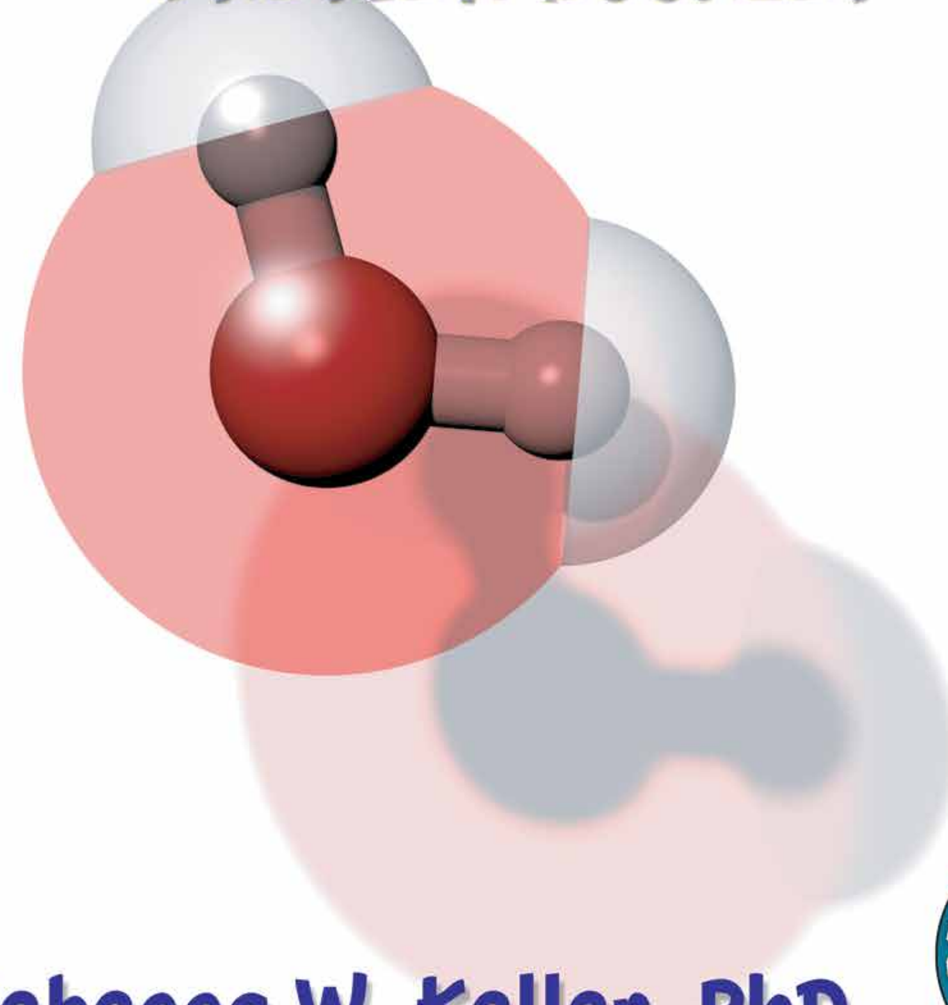
Featuring Chapters from:

Student Textbook
Laboratory Notebook
Teacher's Manual
Lesson Plan
Study Notebook
Quizzes
Graphics Package

Focus On Middle School Chemistry

3rd Edition

PREVIEW BOOKLET



Rebecca W. Keller, PhD

REAL SCIENCE 4 Kids

Introduction

Welcome to the ***Focus On Middle School Chemistry 3rd Edition Preview Booklet*** where you can take our one semester unit study program for a test run!

The materials sampled in this book are taken from a full semester course, with two chapters from each part of the curriculum:

- The ***Focus On Middle School Chemistry Student Textbook–3rd Edition*** provides foundational science concepts presented in a way that makes it easy for students to read and understand. The many colorful illustrations make each chapter fun to look at and reinforce concepts presented.
- With two science experiments for each chapter, the ***Laboratory Notebook*** helps young students learn how to make good observations, an important part of doing science. Open-ended questions help students think about what they are learning, and information is provided to assist students with understanding what they observed while performing their experiments.
- The ***Teacher's Manual*** includes instructions for helping students conduct the experiments, as well as questions for guiding open inquiry. The commonly available, inexpensive materials used for all the experiments can be seen in the complete materials lists included in this booklet.
- Using the ***Lesson Plan*** makes it easy to keep track of daily teaching tasks. A page for each chapter in the ***Student Textbook*** has the objectives of the lesson and questions for further study that connect science with other areas of knowledge, such as history; philosophy; art, music, and math; technology; and language. Forms are included for students to use to do a review of material they've learned and to make up their own test for the chapter. Also included are icons that can be copied onto sticker sheets and used to help plan each day of the week.
- With the ***Study Notebook*** students learn to use critical and creative thinking while exploring their ideas about science. Thought questions are provided, and students are invited to take ownership of their learning by coming up with more questions and by doing research into their areas of interest.
- The one final and two midterm ***Quizzes*** are self-explanatory. For those who are not fans of quizzes, students can use the self-test at the end of the ***Lesson Plan*** instead.
- Another type of teaching aid is provided in the ***Graphics Package,*** which has two full-color images from each chapter of the ***Student Textbook.*** These graphics can be used to create additional teaching aids, such as flash cards, wall posters, PowerPoint lectures, or overhead projections.

Grades 5–8

Focus On Middle School Chemistry

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Real Science 4 Kids

Real Science-4-Kids

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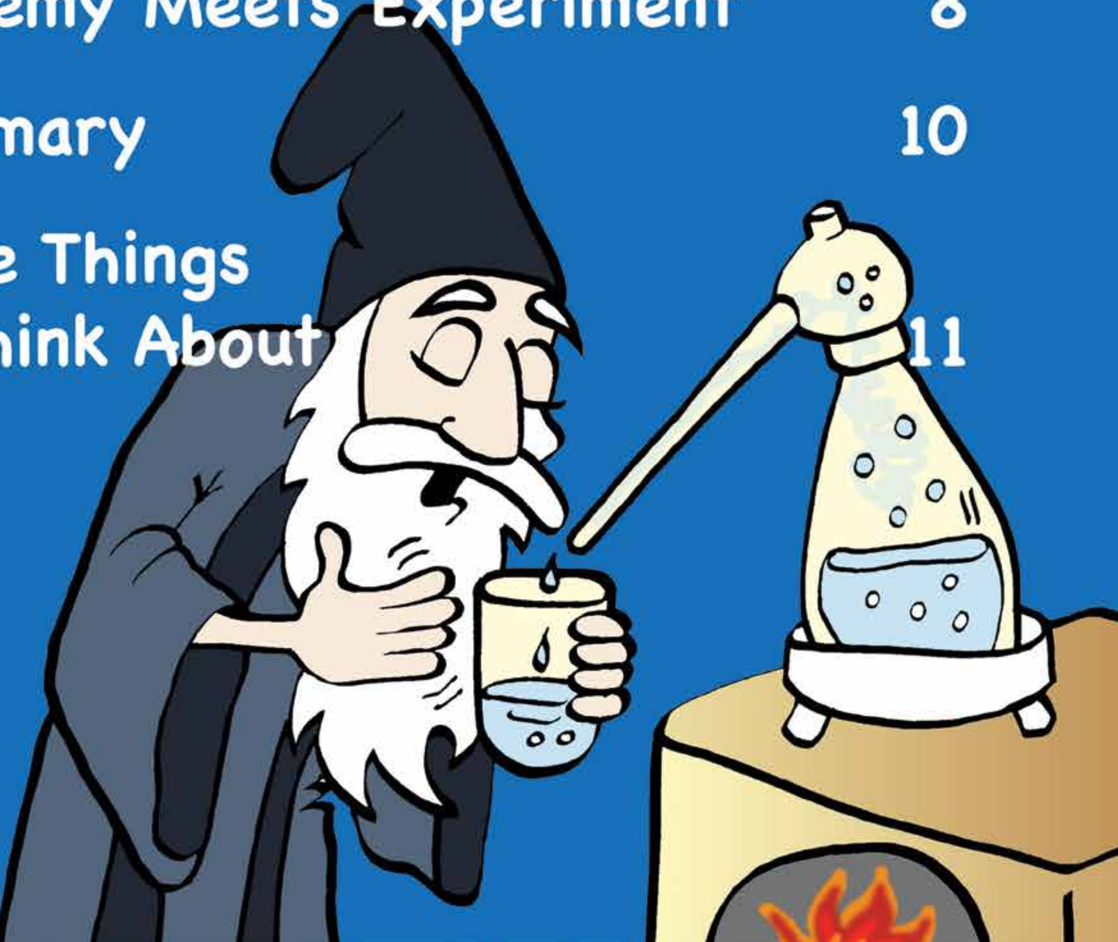
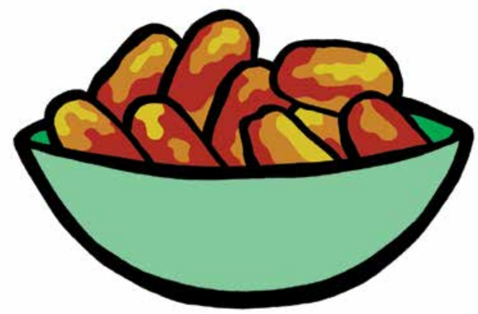


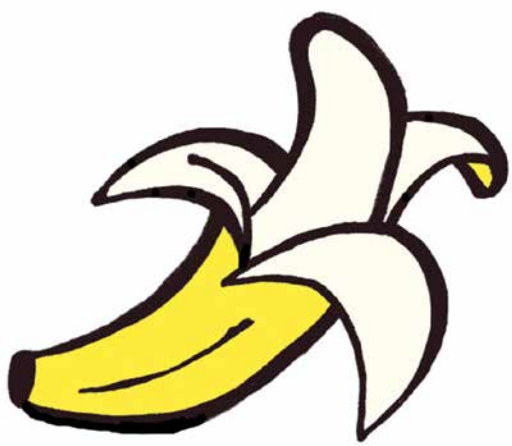
1.1 Introduction

Have you ever wondered what all the objects in the world are made of and why they behave the way they do?



What is soap and why is it slippery? What is air? Why do ice cubes float? Why are dates sweet? What are hair and skin made of? Why is a marble hard and a jellyfish soft?

All of these questions and others like them begin the inquiry into the branch of science we call chemistry.



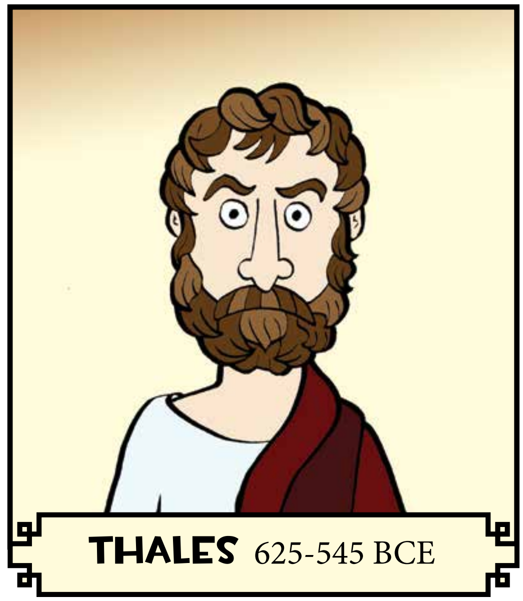
Chemistry is the study of the "stuff" that makes up the things in the physical world. Scientists call this "stuff" matter.

Everything we see with our eyes and can touch with our fingers is made of matter.

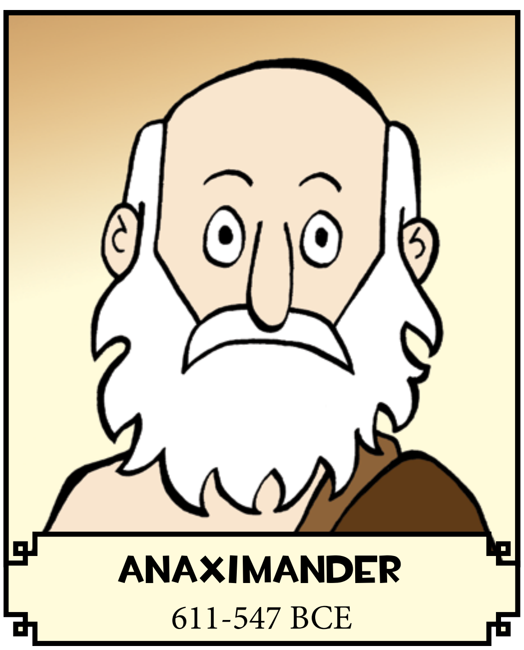
Bananas are made of matter. Cars are made of matter. Even our bodies are made of matter. In Chapter 3 we will learn more about matter and what makes up matter.

1.2 History of Matter

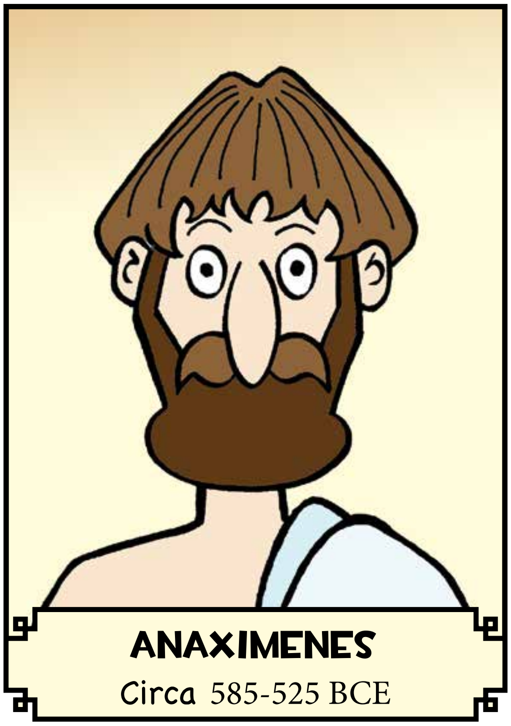
The first person we know of who asked questions about matter was Thales, a Greek philosopher who was born in Miletus, a small trading town on the Aegean coast. Thales studied astronomy and mathematics and is believed to have traveled to Egypt where he learned geometry and astronomy. Thales is credited with bringing this knowledge back to Greece. He used what he knew about the stars to his advantage. One story has it that he bought olive presses for making olive oil because he predicted a large olive harvest. He was right! He made lots of money selling olive oil to everyone.



Thales believed that water was the fundamental unit of matter. He thought that everything in the universe came from water. Thales also felt that water could turn into earth and other types of matter.



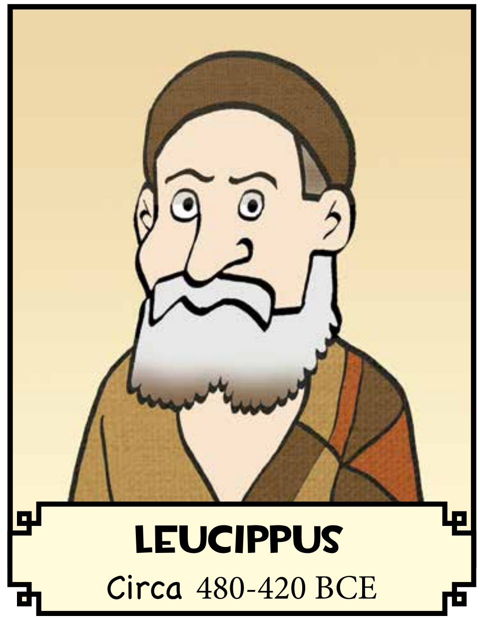
Another Greek philosopher from Miletus who asked about what things are made of was Anaximander. Many of the philosophers who lived during the time that Anaximander was alive were looking for the essence (the true nature of a thing) of all things. These philosophers were curious about what everything is composed of. Anaximander came up with the idea of "the boundless," or "the ultimate." Unfortunately, he never explained what that was, and this was not a lot of help to people.

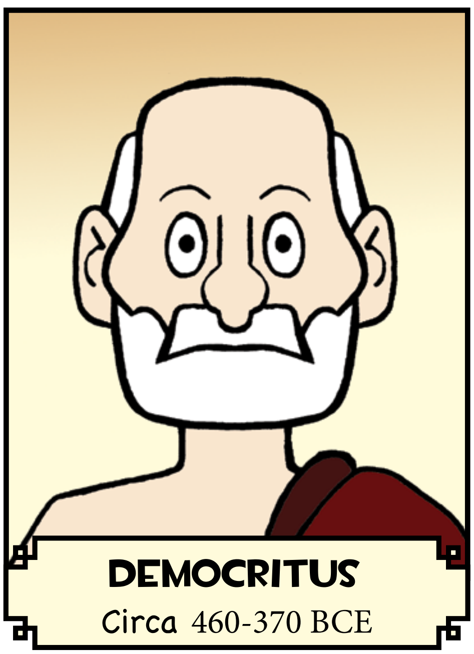


Anaximenes was another Greek philosopher who lived in Miletus and wondered what things are made of. In contrast to Thales, Anaximenes believed that air was the basic substance of matter. According to Anaximenes, when air was thinned, it could become fire. In addition, if air was condensed, it would become wind and clouds. And even more condensing would compress air into water, earth, and even stone. Anaximenes tried to explain many natural processes. For example, he believed that thunder and lightning came from wind breaking out of clouds, that rainbows occurred when the Sun's rays hit the clouds, and that earthquakes took place when the ground dried out after a rainstorm.

Empedocles was all things to all people. Some people believed he was a great healer. Others thought he was a magician. He had some convinced he was a living god. Still others believed he was a total fake. The periodic table of earth, air, fire, and water came from Empedocles. He believed that these four "roots" made up all matter. He believed that even living creatures were composed of these materials.

Another Greek philosopher was Leucippus. We don't know much about Leucippus, but from what we do know, it appears that he was the first person to suggest the idea of empty space. (Today, we would call this a vacuum.) He also developed the idea of atoms. Leucippus believed that different atoms had different sizes and weights. We now know this to be true.





Democritus was another Greek philosopher, and he probably was one of the first weather forecasters. Democritus had people convinced that he could predict the future. He was a student of Leucippus, and he is an example of a pupil who is better known than his teacher. He studied many natural objects, and he gave public lectures.

The Greek philosophers debated about a lot of things. One of their debates had to do with sand on the beach. They asked the following questions: Can you divide a grain of sand indefinitely? — and — Is there a point at which you can no longer break the grain in half?

Most of the philosophers believed that you could divide the grain of sand continuously, without ever stopping. Democritus, however, believed that there was a point at which the grain of sand could no longer be broken into smaller pieces. He called this smallest piece of matter the atom. Today we know that atoms make all matter.

The early Greek philosophers had many arguments over the course of many centuries. They argued about how the world works, how it is made, and how it came into being.

As we saw earlier, Thales thought that everything was made of water. He believed that water was the “primary substance” of all things. He thought that water could not be divided any further. Today we know that water is made of two hydrogen atoms and one oxygen atom.

Anaximander rejected water as the primary substance. As we saw earlier, he thought that everything was made of something that he called “the boundless.” Nobody was really sure what Anaximander meant by “the boundless,” and this made it difficult for him in arguments.

Anaximenes didn’t agree with either Thales or Anaximander. He rejected both water and “the boundless” as the primary substance. He believed that air was the primary substance.

Empedocles disagreed with everyone. He said that all of the things in the world are made up of not just one substance but of four — earth, air, fire, and water.

Democritus and Leucippus didn’t agree with any of the other philosophers either. Democritus and Leucippus thought that the world was made up of atoms. They had trouble explaining exactly what atoms were because they didn’t have the technology to find out about them. However, they thought that all matter is made of one type of thing which they called an atom. They thought that atoms could be combined to make larger things.

It turns out that Democritus’s and Leucippus’s ideas were closer to reality than the other philosophers’ ideas were. But Democritus and Leucippus didn’t get very many people to agree with them. Atoms were not seriously considered as a possibility until the 17th century, almost 2000 years later!

1.3 The Alchemists

Many scholars agree that the word chemistry comes from the word alchemy. The word alchemy comes either from the Egyptian word *khemia* which means "transmutation of earth" or from the Greek word *khymeia*, which means the "art of alloying metals." Both word origins point to the alchemists as the first to experiment with chemistry.

Some early experimenters of chemistry were the alchemists. Alchemists were not considered to be true chemists because they did not approach their work with a scientific method. But they did play with the properties of matter. They believed that they could turn some matter, like lead, into different matter, like gold. A lot of what they tried was based on magic and didn't work. In fact, they never got any lead to turn into gold. Often they would go to a king and ask for money to use to make lead turn into gold. Of course, this never happened. Very often, the king would get angry and put the alchemists in prison (or worse). Sometimes the alchemists would just leave town with the king's money.

Although the alchemists were never successful at turning lead into gold, they did learn quite a lot about the properties of matter. They found out which substances would burn, which substances had a particular taste or smell, and which substances would cause bubbles if mixed with other substances. Through this process, they collected lots of information about the properties of various elements.

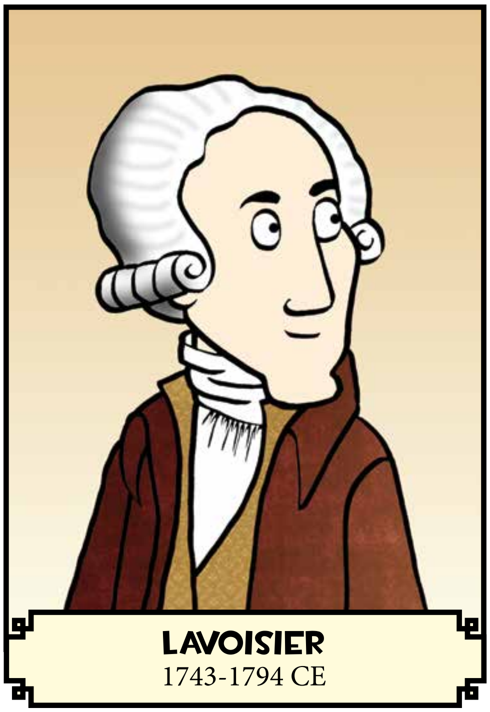
1.4 Alchemy Meets Experiment

The alchemists didn't think that everything was made of air, water, fire, and earth. They thought that everything was made of mercury, sulfur, and salt! But the alchemists weren't right either. By the late 16th and early 17th centuries, modern scientific thinking began to take shape. Philosophy and invention started coming together, and many philosophers began thinking about how to do quality scientific experiments.

One such thinker was Sir Robert Boyle (1627-1691 CE), an Irish chemist and philosopher. Boyle believed in running experiments to see what would actually happen and to prove or disprove his ideas. He used elaborate glassware to test the properties of air and fire, and by doing these experiments, he figured out fundamental gas laws that describe how gases behave under different conditions. Boyle's experiments also helped show that different kinds of atoms could combine to form molecules.

While doing experiments with air, Boyle produced oxygen, but he didn't know it! However, his experiments led to the later discovery of oxygen as an element. By doing quality experiments, Boyle made many contributions to chemistry.

Joseph Priestley (1733-1804 CE) was an English philosopher and chemist who never took a science course. However, he enjoyed playing around with different materials. After he met Benjamin Franklin, Priestley became very interested in science. He discovered carbon dioxide gas and invented the first soda water by adding carbon dioxide to water, a process called carbonation. Carbon dioxide gas makes the fizz in soft drinks. Another of his many discoveries was nitrous oxide, also called laughing gas, which is used for anesthesia. Priestley is also well known for his experiments with oxygen.



Antoine Lavoisier (1743-1794 CE) was a French scientist who believed in performing experiments. He called laboratory work "the torch of observation and experiment." This "torch" shed light on scientific facts. Lavoisier was one of the many scientists who earned the title *The Father of Chemistry*.

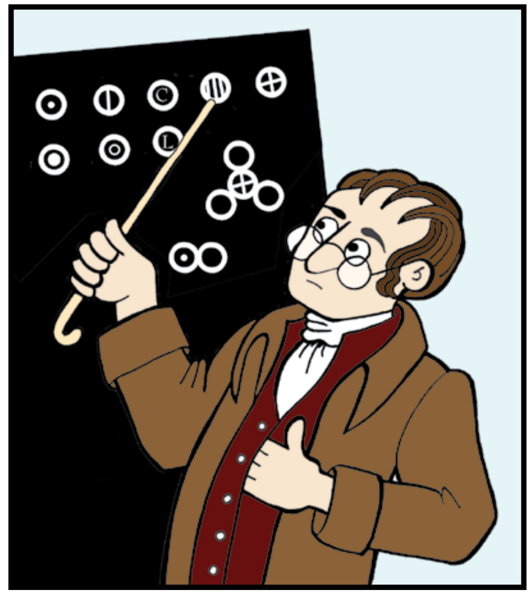
Lavoisier knew Priestley, and Priestley told him about his experiments with oxygen (which Priestley called dephlogisticated air). Lavoisier did his own experiments with oxygen and is the one who gave oxygen its name. Lavoisier tried to take credit for the discovery of oxygen, but it was known that others had discovered it before he did.

Lavoisier showed that water is not a basic substance but is made of oxygen and hydrogen. This was a very important discovery for the advancement of chemistry. Lavoisier wrote his ideas and findings in the well known book *Elements of Chemistry,* which contained useful information for chemists of his time and is still available today.

Although Lavoisier's research and discoveries were important to science, he became unpopular during the French Revolution, which was a time of great turmoil. He was taken prisoner and executed.

By the early 1800s, it was well established that air, fire, water, and earth were not the basic substances. This paved the way for the work of John Dalton (1766-1844 CE). Dalton was a British schoolteacher for most of his life, and he first became interested in science by studying the weather.

Dalton revived the hypothesis for the atomic theory of elements that had been proposed by Democritus some 2000 years earlier. In his published work, *A New System of Chemical Philosophy,* consisting of several volumes written between 1808 and 1827, Dalton proposed that all elements are made of atoms. He also proposed that each element has its own atomic weight. The atomic weight, he said, is proportional to the size of the atom that makes up the element. This agrees with what we know today.



Dalton drew the first table of elements. In the table, he described the arrangement of the atoms in several elements, and he provided their atomic weights. Dalton did not know all of the elements that we know today, but he laid the foundation for future study. His contributions to the field of chemistry were significant. John Dalton is known as the *Father of Modern Chemistry*.

Dalton's atomic theory tried to explain some basic properties of atoms. He had the right idea, but several points in his theory were later proven incomplete. Today, we know that atoms make up matter and that the model of the atom is a good explanation for how matter works. Like the alchemists, modern chemists continue to experiment with finding ways to change matter from one type to another. Because they understand about atoms, they've even figured out how to change lead into gold!

1.5 Summary

- Chemistry is the study of the matter that makes up the physical world.
- Early Greek philosophers had different ideas about what matter is made of and had many arguments about how the world works.
- The alchemists experimented with matter and tried to turn lead into gold.
- By doing quality experiments, early scientists were able to show that the basic unit of matter is the atom.

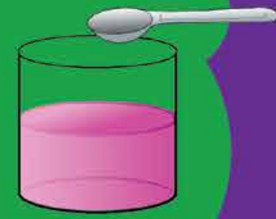
1.6 Some Things to Think About

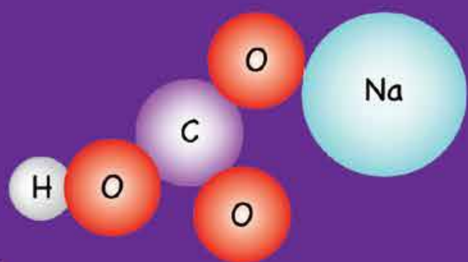
- Why do you think it is important to ask questions when doing chemistry?
- Describe some of the different ideas philosophers had about matter.
- Why do you think philosophers argued about their ideas?

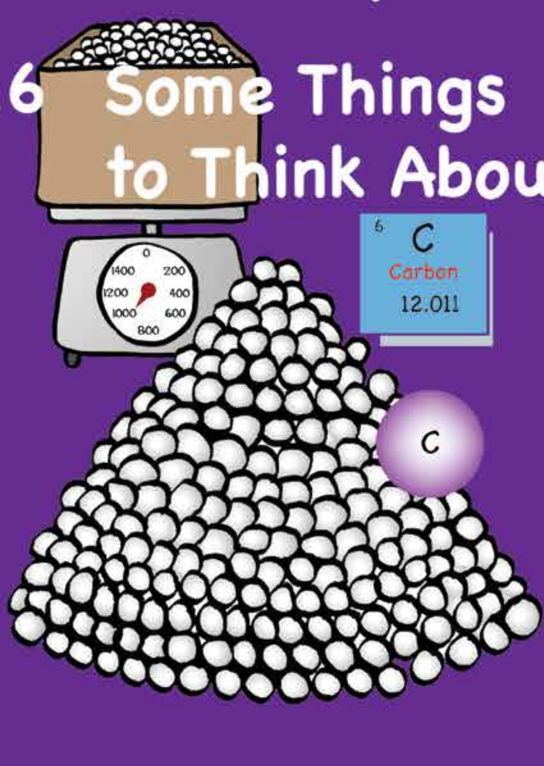
  Do you think the philosophers' arguments were helpful in the development of theories about matter? Why or why not?
- Even though alchemists are not considered true chemists, how do you think their studies advanced science?
- Explain how the studies of Sir Robert Boyle, Joseph Priestley, Antoine Lavoisier, and John Dalton led to advances in chemistry.

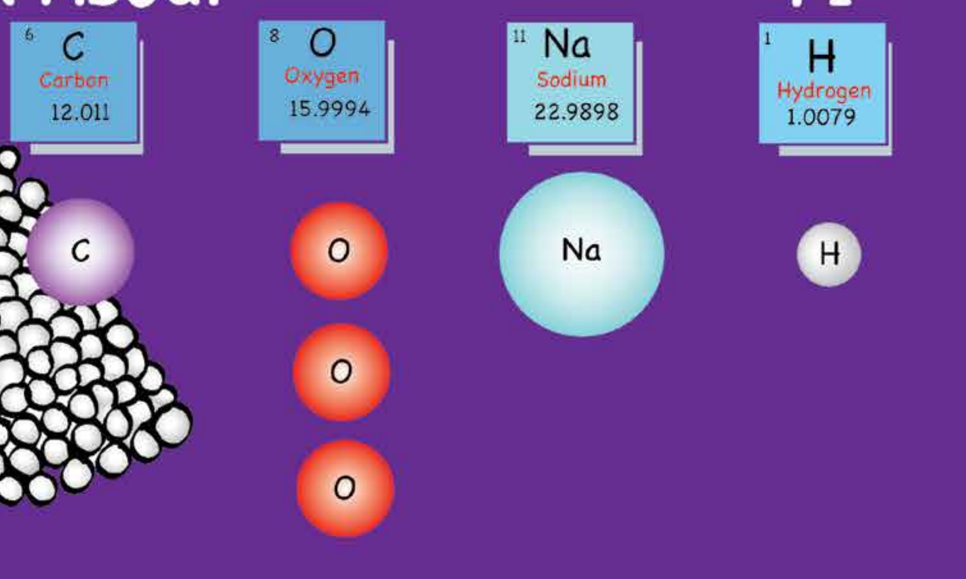
  Do you think each of these scientists could have made the same discoveries without knowing about the work of the others? Why or why not?

Chapter 7 Acid-Base Neutralization





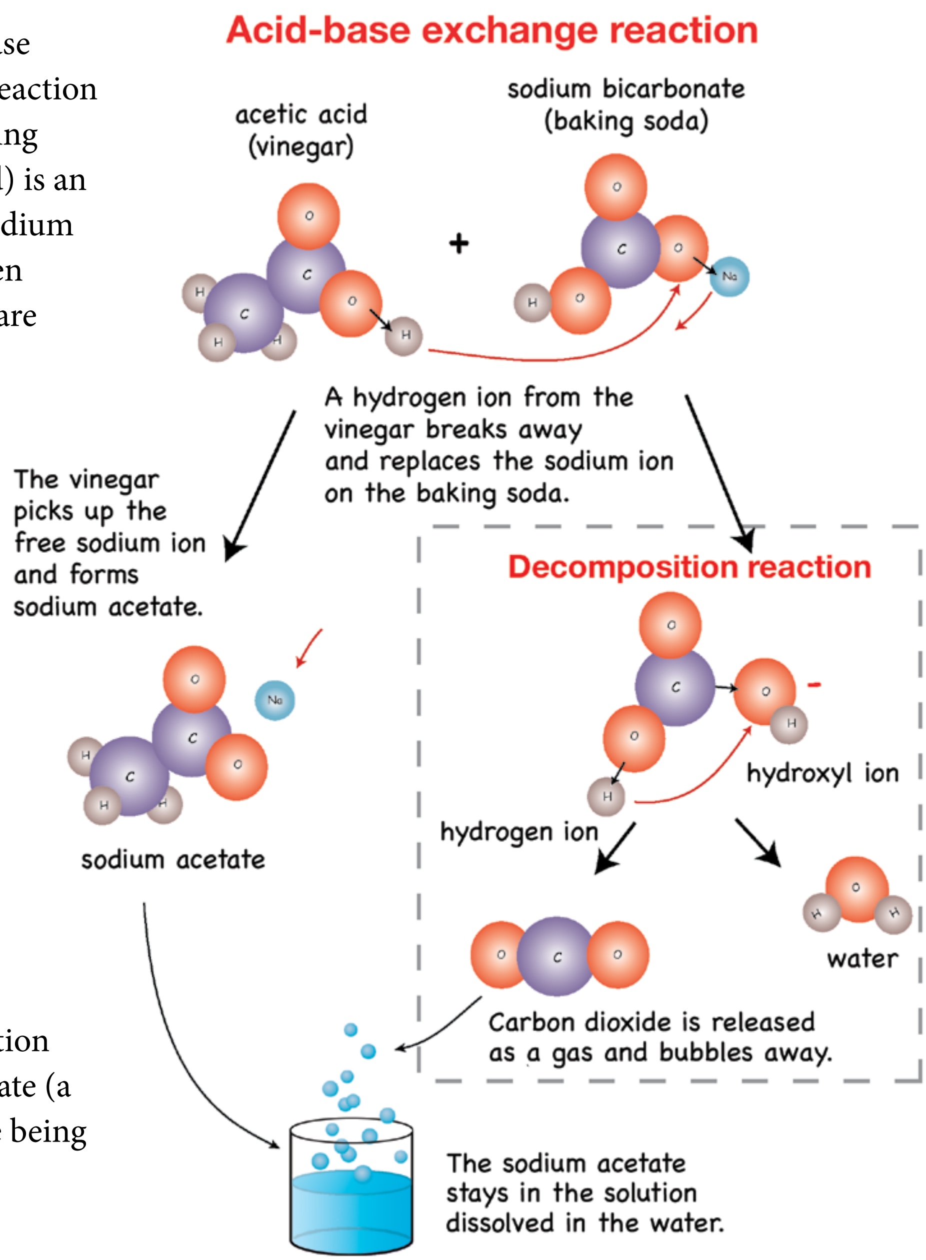




7.1 Introduction

When an acid is added to a base, or a base is added to an acid, an acid-base reaction occurs. An acid-base reaction is a special type of exchange reaction. Recall that in an exchange reaction atoms in one molecule trade places with atoms in another molecule.

An example of an acid-base reaction is the chemical reaction between vinegar and baking soda. Vinegar (acetic acid) is an acid, and baking soda (sodium hydroxide) is a base. When vinegar and baking soda are mixed in water, one of the hydrogen atoms of the vinegar trades places with the sodium atom of the baking soda. However, there is a second step — a decomposition reaction in which the intermediate products break apart and make carbon dioxide and water. You can see that the end product of the reaction between vinegar and baking soda is a solution of water and sodium acetate (a salt), with carbon dioxide being given off as gas bubbles.



An acid-base reaction is also called a neutralization reaction. When an equal concentration of a strong acid reacts with an equal concentration of a strong base, the resulting solution becomes neutral — neither acidic nor basic — because all the molecules of both the acid and the base have reacted with each other.

Another way of saying this is that when an acid reacts with a base, the atoms that make the acid acidic (hydrogen ions) react with the atoms that make the base basic (hydroxide ions) to form water and a salt. When this happens, the acid and base neutralize each other.

As an example of an acid being neutralized, you might think about a person who gets acid indigestion after eating too many chili cheese fries. Acid indigestion results when the stomach has produced too much acid and the excess acid causes pain. Taking an antacid can reduce the pain because an antacid is a base and when eaten will neutralize stomach acid. Antacids are not very strong (not concentrated) so they are safe to eat when the need arises.

7.2 Titration

Why do we need to take antacids that are not very concentrated? How can we be sure that the antacid we take is not too strong but just strong enough to fix our indigestion? If we have an acid or a base, how can we know whether it has a concentration that is safe for us to use?

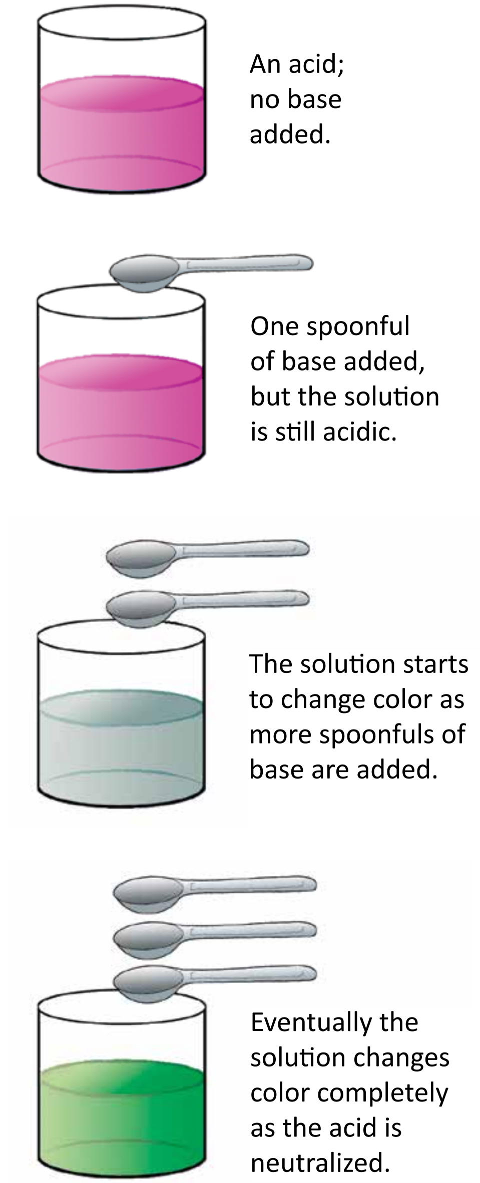
As it turns out, chemists can determine how concentrated and how strong an acid or a base is by using a technique called a titration. The word titration comes from the old French word *titre* which means assay. An assay is a test of quality. By doing an acid-base titration, a chemist can test for the quality of an acid or base solution — how strong, weak, or concentrated it is.

The fundamental idea behind a titration is to use a solution of an acid or base of known concentration to find the concentration of an unknown acid or base solution. An acid-base indicator or a pH meter is used to observe the acid-base reaction during the titration.

To do a titration, an acid is added to a base or a base is added to an acid, and the pH of the solution is observed as it changes. If the acid or base is added a little at a time, the pH of the solution will change slowly enough to be observed by a pH meter or acid-base indicator.

For example, if the titration starts with a beaker full of vinegar and red cabbage juice acid-base indicator, the color of the liquid will be a bright pink. If one spoonful of baking soda is added, there is not enough base to completely neutralize the acid, so the solution will still be pink. However, if more spoonfuls of baking soda are added one at a time, eventually there will be enough base to neutralize the acid, and the acid-base indicator will change color.

By plotting the data on a graph, the concentration of the unknown acid or base can be determined. Before we see how this works, let's take a look at how to plot data.



7.3 Plotting Data

One way to examine a titration in detail is to plot or graph the data. A plot is a handy visual tool that scientists use to help them understand data. Plots can be made of almost any data. For example, you might notice that the older members in your family are usually taller than the young members, so you could say that there is a connection between age and height. A plot can be made to illustrate the relationship between age and height.

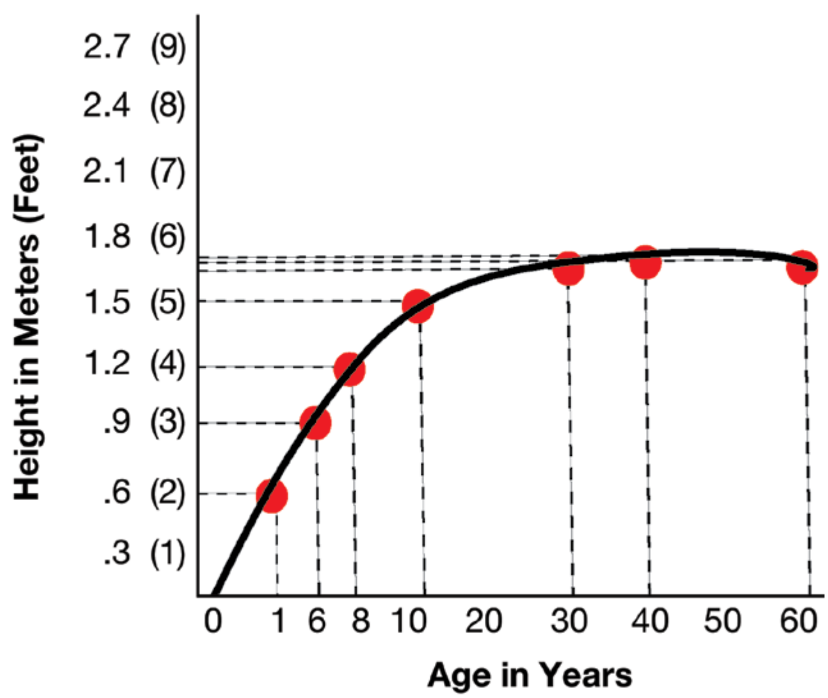
To make a plot of age vs. (versus) height, the first step is to gather the data to be plotted. For this example, the data might look something like the following.

Age	Height
Age 1	.6 m (2 ft)
Age 6	.9 m (3 ft)
Age 8	1.2 m (4 ft)
Age 11	1.5 m (5 ft)
Age 30	1.7 m (5.5 ft)
Age 40	1.8 m (5.8 ft)
Age 60	1.75 m (5.75 ft)

Once the data has been collected, the plot can be created. First, a horizontal line is drawn. This line is called the x-axis. Another line is drawn perpendicular (vertically) to the first and meets the first line at the bottom of the left-hand side. This vertical line is called the y-axis.

To plot the data in this example, the x-axis is labeled "age" and the y-axis is labeled "height." The age of the person is marked on the graph with a vertical dotted line, and the height of the person is marked with a horizontal dotted line. The point where the two lines intersect is marked with a red dot, called a point. A solid black line can then be drawn to connect all the points on the plot.

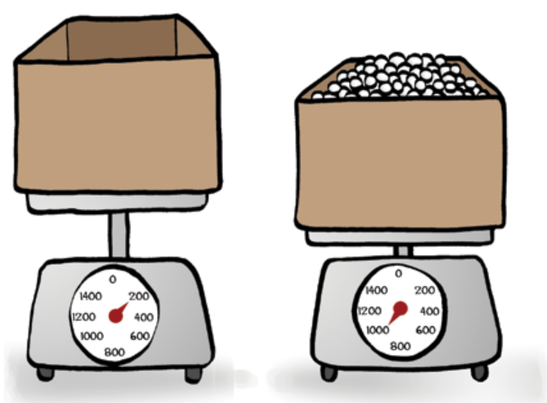
From this plot we can tell that, in general, as a person gets older, they grow taller. (The drawn black line goes up as the age goes up.) This graph also shows that a person stops growing when a certain age is reached. (The drawn black line levels off, showing that no significant growth occurs after age 20 or so.) Plotting is a tool that scientists use to organize their data in a way that makes it easier to understand.



7.4 Plot of an Acid-Base Titration

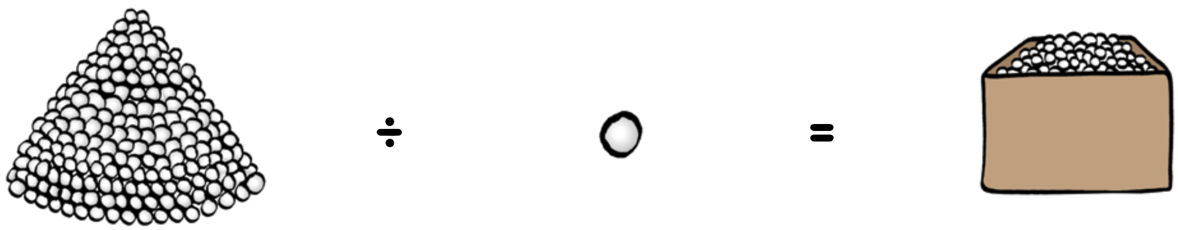
Let's take a closer look at how to plot an acid-base titration and how to find out the concentration of an unknown acid or base. Imagine that we have a beaker half-full of household vinegar. We know that household vinegar is made of acetic acid molecules, but we may not know how many acetic acid molecules the beaker contains. In other words, we don't know how concentrated our household vinegar is. Imagine that we also have a box of baking soda. Using a scale we can measure the weight of the baking soda. By knowing the weight of the baking soda, we know how many molecules it has.

Wait! How can we know this? Let's use a box of ping-pong balls as an example. Imagine you have a box full of ping-pong balls. You don't know how many ping-pong balls you have, but you can find out the weight of one ping-pong ball. You can then calculate the total number of ping-pong balls. First, by dumping out all the ping-pong balls and weighing the empty box, you can get the weight of the box alone. Next, if you put all the ping-pong balls back in the box and weigh the full box, you can get the total weight. Now you can subtract the weight of the empty box from the total weight of the box with the ping-pong balls in it to find out the weight of all your ping-pong balls together.



Total weight (1000 grams)	–	Box weight (200 grams)	=	Total weight of ping-pong balls (800 grams)

If you then divide the weight of all the ping-pong balls by the weight of one ping-pong ball, you can calculate how many ping-pong balls you have.

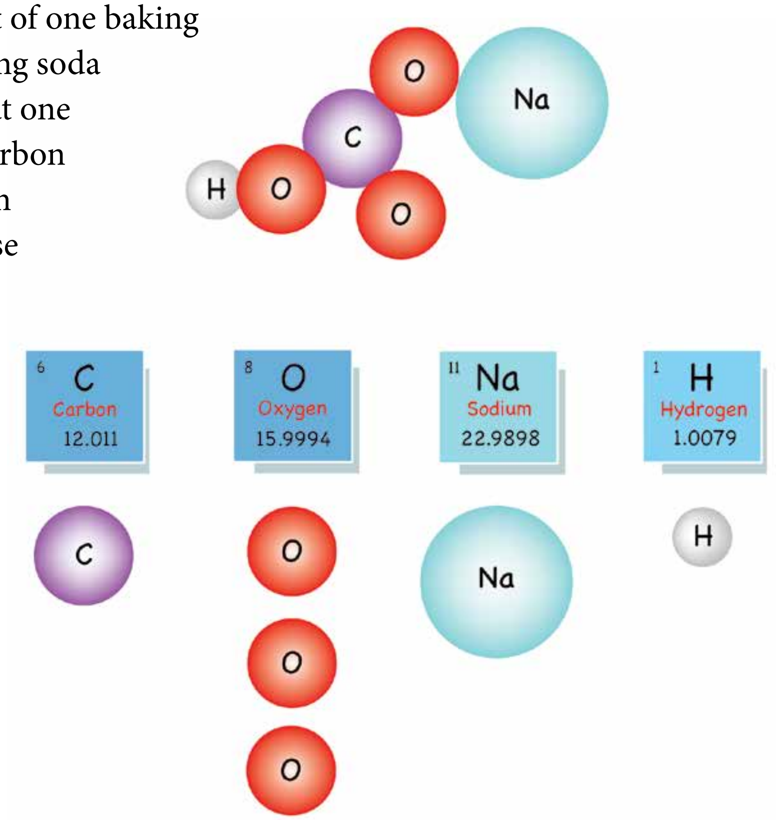


Total weight of ping-pong balls (800 grams) ÷ Weight of one ping-pong ball (8 grams) = Number of ping-pong balls (100)

The same is true for calculating how many molecules you have in a given amount. If you have a teaspoonful of baking soda that weighs 100 grams and you know the weight of one baking soda molecule, you can figure out the number of baking soda molecules in 100 grams.

But wait! How do we know the weight of one baking soda molecule? We can't weigh a baking soda molecule directly, but we do know that one baking soda molecule contains one carbon atom, three oxygen atoms, one sodium atom, and one hydrogen atom. Because we can use the periodic table of elements to find the atomic weight of each atom, we can add the atomic weights of all the atoms together to get the molecular weight — the weight of one molecule.

We can see that the molecular weight of sodium bicarbonate is 84 amu. But wait! What is an amu and how many grams is that? An amu is a measure of the atomic mass of an atom. Amu stands for atomic mass units. An atomic mass unit is equal to 1/12th the mass of a carbon atom.



1x12 amu + (3x16 amu) + (1x23 amu) + (1x1 amu) = (84 amu)

As you can imagine, one atomic mass unit is a very small number. In fact, this number is so small that it is not useful for chemists doing chemistry calculations. Instead of using atomic mass units, chemists figured out how to measure the weight of a group of atoms. This group of atoms is called a mole. A mole is just a name that is used to represent a certain number of "things." These "things" can be atoms, molecules, ions, or even oven mitts or baseball caps. A mole is a way to count atoms and molecules just like a dozen is a way to count eggs. The only difference is that a mole is a very large number.

One mole = 602,200,000,000,000,000,000,000
(6.022×10^{23})

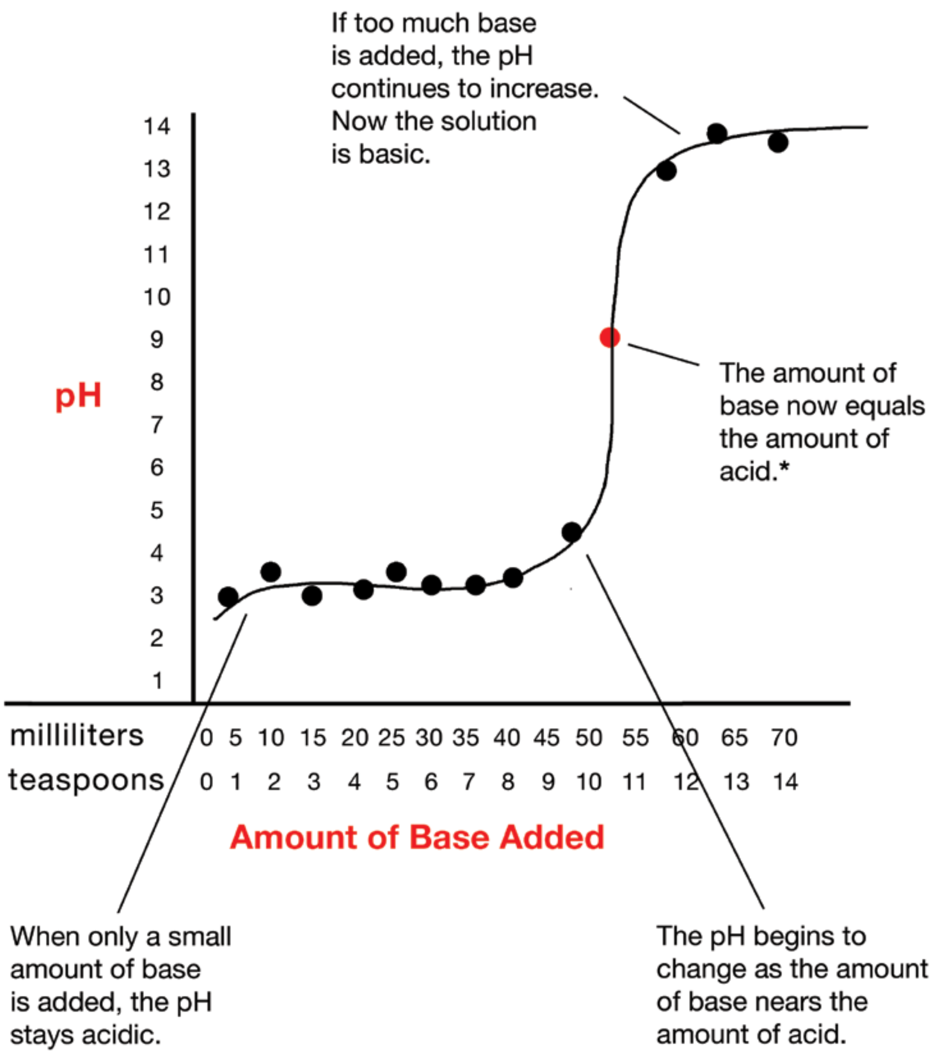
A mole is 6022 followed by 20 zeros, and it's such a big number that it won't even fit on most calculators. It's so big that if you had a mole of marbles, it would be bigger than the Moon! But atoms are very tiny, so a mole of atoms is a nice, manageable size. A mole of most atoms will fit in the palm of your hand.

This big number for one mole is called Avogadro's constant and is named after Italian scientist Amedeo Avogadro who had the idea that the number of gas molecules in a given volume is the same no matter what kind of gas it is. Based on his idea, Avogadro was able to calculate the number of molecules in the given volume. Today, Avogadro's number is used to relate the number of atoms and molecules to their atomic and molecular weights.

By definition, one mole of carbon atoms equals 12 grams, one mole of hydrogen atoms equals 1 gram, and 1 mole of sodium bicarbonate molecules equals 84 grams. This comes in very handy for acid-base reactions. Instead of worrying about the number of molecules needed to neutralize a reaction, we can use the number of moles. One mole of sodium bicarbonate will neutralize one mole of vinegar. We know that one mole of baking soda weighs 84 grams and we can measure this on a scale!

Now that we know that 84 grams of baking soda equals one mole, we can use a titration to find out how many moles of acid are in a solution. Let's go back to the titration of vinegar and baking soda. We have a beaker half-full of vinegar and we have a box of baking soda. Using a scale we can measure how much a teaspoonful of baking soda weighs in grams. We also know that one mole of baking soda will neutralize one mole of vinegar.

By using a pH meter or an acid-base indicator, we can see the pH of the solution change as we slowly add baking soda to the vinegar. We can record the pH change for each teaspoon of baking soda added and then plot a graph from this data. The graph may look something like the one following.



* In this example the pH is slightly higher than 7 at the neutralization point because the product of the reaction, sodium acetate, is slightly basic.

The x-axis (horizontal) is labeled *Amount of Base Added*, and the y-axis (vertical) is labeled *pH* but could also be labeled *Color*. Notice that the graph looks like a snake with two curved sections. The midpoint between the two curved sections is the point where the amount of base equals the amount of acid. If you know how many moles of base are in a teaspoonful and you know how many teaspoonfuls were added, you know how many moles of base it takes to neutralize *all* the acid. Therefore, you know how many moles of acid were in the beaker you started with!

You Do it!

1. If it takes 84 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?
2. If if takes 42 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?
3. If if takes 168 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?

(See end of chapter for solutions.)

7.5 Summary

- An acid-base reaction is a special type of exchange reaction.
- An acid and a base neutralize each other in an acid-base reaction.
- Equal amounts of acid and base completely neutralize each other.
- Plotting data can make it easier to understand.
- A mole is the name for a certain number of atoms, molecules, or ions.
- The concentration of an unknown acid or base can be found using a titration.

7.6 Some Things to Think About

- Explain how an acid-base reaction occurs.
- Why do you think a chemist would use an acid-base indicator or a pH meter during a titration?
- What do you think the results of a titration would tell a chemist?
- Review the chart of data and the plot in Section 7.3 and compare how easy or difficult it is to interpret and read data on each. Do you think there are times when you would want to use a chart and times when using a plot would be better? Why?

  When do you think you might want to use both? Why?

(You Do It! solutions on next page.)

You Do It! – Solutions

Acid-Base Neutralization

We know that 84 grams of baking soda equals one mole (pages 67-68).

We also know that one mole of baking soda neutralizes 1 mole of acetic acid (page 68). Looking at the illustration on page 62, we can see that there are the same kind and number of atoms in the molecules before the reaction and in the new molecules that result from the reaction. We can write the reaction as:

$$\underset{\text{acetic acid}}{CH_3COOH} + \underset{\text{baking soda}}{NaCO_3H} \text{ -------> } \underset{\text{sodium acetate}}{NaCH_3COO} + \underset{\text{carbon dioxide}}{CO_2} + \underset{\text{water}}{H_2O}$$

Because we know how the atoms and molecules behave during the reaction, we can see that 2 moles of baking soda will neutralize 2 moles of acetic acid, 3 moles of baking soda will neutralize 3 moles of acetic acid, 0.5 moles of baking soda will neutralize 0.5 moles of acetic acid, and so on.

The questions in this *You Do It* section ask how many moles of acid are neutralized by 84 grams, 42 grams, and 168 grams of baking soda. In each case all we need to do to solve the problem is to convert grams of baking soda to moles of baking soda. Since an equal concentration of baking soda will neutralize an equal concentration of acetic acid, we know that the number of moles of baking soda and the number of moles of acetic acid will be the same.

To convert grams to moles we use a "conversion factor." A conversion factor states mathematically the relationship between two quantities. For baking soda we can write our conversion factor as:

$$\frac{1 \text{ mole}}{84 \text{ grams}} \quad \text{or} \quad \frac{84 \text{ grams}}{1 \text{ mole}}$$

(Continued on next page.)

You Do It! – Solutions (cont.)

Acid-Base Neutralization (cont.)

To solve these problems, multiply the number of grams by the conversion factor.

1. If it takes 84 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?

$$\cancel{84 \text{ grams}} \times \frac{1 \text{ mole}}{\cancel{84 \text{ grams}}} = 1 \text{ mole}$$

There is 1 mole of acetic acid that is neutralized by 84 grams of baking soda.

2. If if takes 42 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?

$$42 \text{ grams} \times \frac{1 \text{ mole}}{84 \text{ grams}} = 0.5 \text{ mole}$$

0.5 mole of acetic acid is neutralized by 42 grams of baking soda.

3. If if takes 168 grams of baking soda to neutralize a beaker of acetic acid, how many moles of acetic acid do you have?

$$168 \text{ grams} \times \frac{1 \text{ mole}}{84 \text{ grams}} = 2 \text{ moles}$$

2 moles of acetic acid are neutralized by 168 grams of baking soda.

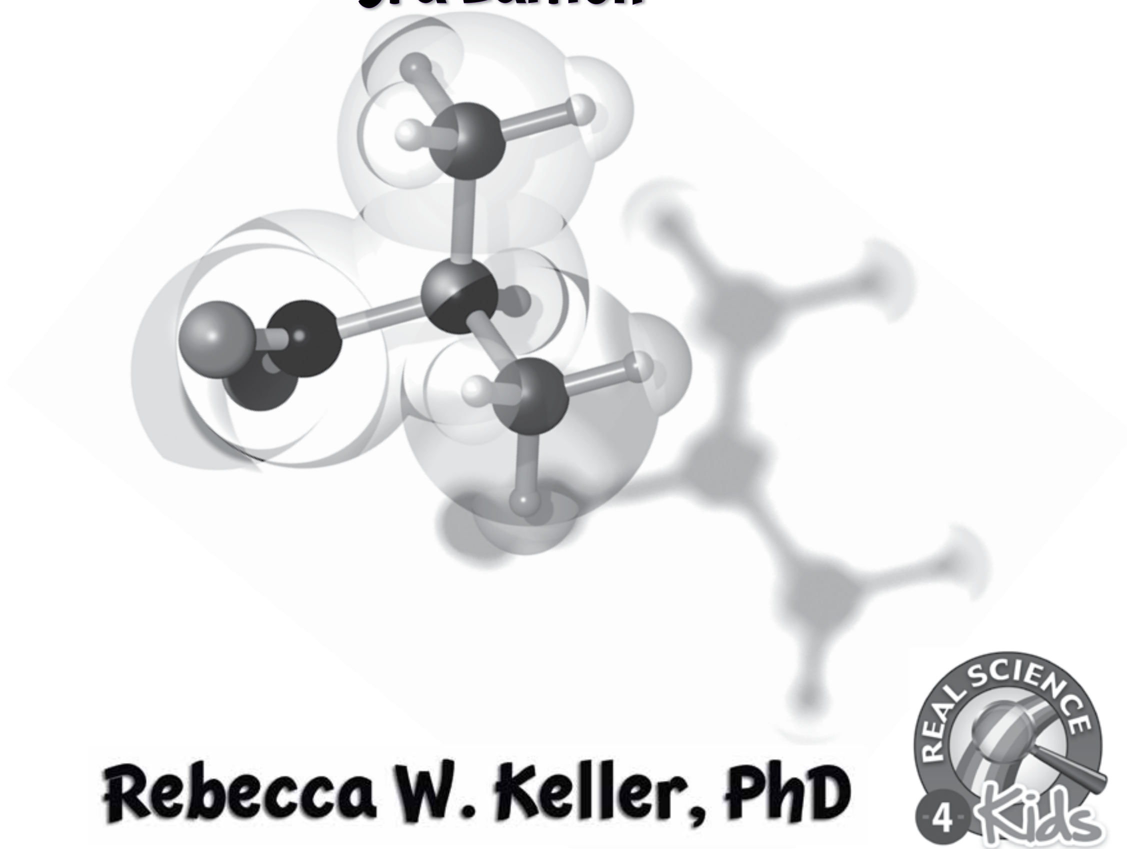
FOCUS ON

Grades 5-8

MIDDLE SCHOOL CHEMISTRY

Laboratory Notebook

3rd Edition



Rebecca W. Keller, PhD

Real Science-4-Kids

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Keeping a Laboratory Notebook

A laboratory notebook is essential for the experimental scientist. In this type of notebook, the results of all the experiments are kept together along with comments and any additional information that is gathered. For this curriculum, you should use this workbook as your laboratory notebook and record your experimental observations and conclusions directly on its pages, just as a real scientist would.

The experimental section for each chapter is pre-written. The exact format of a notebook may vary among scientists, but all experiments written in a laboratory notebook have certain essential parts. For each experiment, a descriptive but short *Title* is written at the top of the page along with the *Date* the experiment is performed. Below the title, an *Objective* and a *Hypothesis* are written. The objective is a short statement that tells something about why you are doing the experiment, and the hypothesis is the predicted outcome. Next, a *Materials List* is written. The materials should be gathered before the experiment is started.

Following the *Materials List,* the *Experiment* is written. The sequence of steps for the experiment is written beforehand, and any changes should be noted during the experiment. All of the details of the experiment are written in this section. All information that might be of some importance is included. For example, if you are to measure 1 cup of water for an experiment, but you actually measured 1 1/4 cup, this should be recorded. It is hard sometimes to predict the way in which even small variations in an experiment will affect the outcome, and it is easier to track down a problem if all of the information is recorded.

The next section is the *Results* section. Here you will record your experimental observations. It is extremely important that you be honest about what is observed. For example, if the experimental instructions say that a solution will turn yellow, but your solution turned blue, you must record blue. You may have done the experiment incorrectly, or you might have discovered a new and interesting result, but either way, it is very important that your observations be honestly recorded.

Finally, the *Conclusions* should be written. Here you will explain what the observations may mean. You should try to write only valid conclusions. It is important to learn to think about what the data actually show and what cannot be concluded from the experiment.

Contents

Experiment 1

Learning to Argue Scientifically

Introduction

In science, to "argue" means to present your point of view to someone who has an opposite or different point of view. An "argument" is the logic and data you used to arrive at a particular conclusion as well as a back and forth discussion. This experiment will help you learn how to argue like a scientist!

I. Think About It

❶ Think about a situation where you need to argue your side, or point of view, with a sibling or friend. Describe how you feel when you think about arguing your side. Do you feel calm or anxious? Do you feel excited or scared?

❷ Describe what happens in your body as you think about arguing your side. What do you think would help you stay calm as you argue your side?

❸ Think about a situation where you need to argue your side with a parent, teacher, or another adult. Describe how you feel as you think about arguing your side. Do you feel calm or anxious? Do you feel excited or stressed?

❹ Describe what happens in your body as you think about arguing your side with a parent, teacher, or another adult. What do you think would help you stay calm as you argue your side?

❺ Is it easier to argue your side with a friend/sibling or with a parent/teacher or other adult? Why?

II. Experiment 2: Learning to Argue Scientifically—A Thought Experiment

Date __________

A thought experiment is done by thinking scientifically about how something might work without actually doing an experiment.

Objective To explore the importance of using scientific data to support scientific conclusions

Hypothesis By arguing with others about my ideas and using data to support my conclusions, I can learn about my own research and learn from others who may oppose my conclusions.

Materials

imagination

EXPERIMENT

❶ Read the following play.

The Mystery of Substance: A Philosophy Play
By D. R. Megill

ANAXIMANDER—believed everything is made up of "the boundless"

ANAXIMENES—believed everything is made up of air

THALES—believed everything is made up of water

DEMOCRITUS—believed everything is made up of atoms

Anaximander, Anaximenes, and Thales are having a heated argument. They are standing in a circle.

in the center of the city, Democritus is sitting on the ground building or playing with some sort of weird, unrecognizable materials [Legos]. It appears that Democritus is barely listening.

THALES: But it's obvious that everything comes from water! The very nature of life speaks to this. We could not live without water! Notice what happens when water is absent from a land for any period of time! It becomes barren, empty. Everything dies. Other forms of life come from water too: fish, frogs, and so on. Even our friend Democritus here on the ground (What are you doing, Dem?) must come from water.

ANAXIMANDER: But surely you see that there are things that could not possibly come from water. Things like earth and fire most certainly do not come from water.

THALES: Hmmm. Yes, fire presents a difficulty, considering that water destroys fire.

ANAXIMENES: I think you may have water on the brain, Thales. Rain drops from air. Thus, I am convinced by this, and by other proofs, that air is the source of all things! Air may take on different forms according to its different properties. In a rarefied form, it could even become fire. Fire can be destroyed not only by the addition of water, but more importantly, by the subtraction of air. This again, is proof of my point!

ANAXIMANDER: If Thales's head is full of water, does that mean yours is full of air, friend Anaximenes? I fear you are both wrong, but I don't fault you for it. It is very difficult to identify what things are made of.

THALES: You feel, no doubt, that you have done so?

ANAXIMANDER: Truth be told, yes, I have. It is hard to identify because we do not see it. We see only the parts into which it has been broken. Obviously, if it is the substance from which all things come, we cannot expect to see it in its initial form. We can, though, guess its nature from that which we do see. Tell me, what is true of everything?

ANAXIMENES: Everything has a purpose, I suppose.

THALES: *(looking down at Democritus on the ground)* Democritus here proves otherwise, Anaximenes. He serves no purpose at all, except to tinker with his strange objects.

ANAXIMANDER: No, no, I will tell you what is true of all things. Everything has an opposite! Everything is equally balanced and measured by its opposite. If we could put all these things of opposite nature together, we would get a picture of a perfectly balanced, limitless substance. I call it, therefore, the boundless.

THALES: But what is the boundless, Nax?

ANAXIMANDER: I just told you. It is the thing from which all other things come.

ANAXIMENES: No, you just described it. What is it?

DEMOCRITUS: *(laughing in derision and without looking up)* You will never get the answer to that, my friends. He does not know! He is trying to befuddle you with fancy talk and imprecise terms. He speaks of a boundless, but it is only his imagination that is boundless, not his reasoning. You ask what all things are made of, and he answers that it is that from which all others come. Round and round it goes; where it stops, nobody knows.

ANAXIMANDER: I suppose you could do better then!

DEMOCRITUS: If you truly care to listen to the truth, you would be one of very few.

THALES: Well, I say we let him try, but for Zeus's sake, please stand up and look at us when you talk, as civil people do.

DEMOCRITUS: Well, I never claimed to be civil, but perhaps the argument will be a good break from my current exploration. (standing up) You are familiar, I hope, with the only reasonable man in Miletus, Leucippus.

ANAXIMANDER: Of course.

DEMOCRITUS: Well then, if you are familiar with Leucippus, perhaps this will sound familiar to you. I have only followed Leucippus's reasoning and observations to their obvious conclusion. There are two distinct problems. One is the problem of change, and the other is the problem of divisibility.

ANAXIMENES: What?

DEMOCRITUS: Things change. Haven't you noticed? How does a thing change from a basic substance into another thing? How can such a change be possible? As Empedocles of Elea has argued, change is rationally impossible, as it requires the existence of what is not.

ANAXIMANDER: And you accuse me of being obscure!

DEMOCRITUS: Let's leave the problem of change for now, and let's examine the other problem: divisibility. Imagine any element that you regard as the basic substance of things. It matters not what it is. Just imagine it. Now, divide it in half.

THALES: What? But what does that . . .

DEMOCRITUS: Can you do it? Can you picture dividing that substance in half?

THALES: Well, yes, of course, but . . .

DEMOCRITUS: Then that cannot be the basic substance. If it can be divided at all, it is not yet the basic substance. Rather, the two halves that you divided it into are the basic substances. Right?

THALES: Well, yes, you're right. But then, of course, that could be divided again.

DEMOCRITUS: Exactly! I am saying that, by definition, the most basic substance must be that which is no longer divisible.

ANAXIMENES: But no one has ever seen such a thing.

DEMOCRITUS: Of course no one has ever seen such a thing. Such a thing would be invisible to the naked eye. However, when combined with others of its kind, they would become visible. As you can see, the combinations by which these "indivisibles," or atoms, could combine would be virtually numberless, and by combining in different ways, they would make different things. This would explain the appearance of change by things that ultimately do not change.

THALES: Your ideas are nonsense, Democritus.

Democritus (begins laughing)

ANAXIMANDER: You are entertaining, Democritus, but obviously, going mad. It's clear by the way you go about laughing at everything all the time.

DEMOCRITUS: If you could see how ridiculous you all are, you and all the others, you would laugh too.

ANAXIMENES: I fear my friends are right. You are clearly either crazy or stupid. These toys of yours, Democritus, what are they?

DEMOCRITUS: I knew you would not listen. Now, if you don't mind, I'd like to get back to my current exploration. *(Democritus kneels back down on the ground.)* If you must know, my nephew invented these. They are a good example of my atomic ideas. These little pieces can be rearranged into various shapes and can be used over and over without any seeming decay. My nephew has named them after his father, my brother, Legosus.

THALES: You have to admit, guys, that water is almost as indivisible as Democritus. I told you I was right.

Anaximander, Anaximenes, and Thales begin walking away from Democritus.

ANAXIMENES: *(to Thales)* You are as crazy as he is.

ANAXIMANDER: I'm telling you, it's the boundless. Let me show you.

(END)

❷ According to Democritus, what is the primary substance? Explain his description.

____

____

____

____

____

____

❸ Do the other philosophers believe Democritus? Why or why not?

❹ List some points made by each of the philosophers.

ANAXIMANDER

ANAXIMENES

THALES

DEMOCRITUS

Results

❶ If you lived in ancient Greece and didn't know what we now know about matter, which of the philosophers' arguments would you have found most convincing? What points did he make that convinced you?

❷ Imagine that you are a young Einstein working as a clerk in a patent office. You come up with a radical new idea for how light and matter interact. This idea goes against the standard scientific theories of the day and is opposed by many established scientists. How would you argue for your discovery?

III. Conclusions

What conclusions about arguing scientifically can you draw from your observations?

IV. Why?

By doing thought experiments, you can get an idea for how an experiment or argument may go without having actual data. Thought experiments are useful because they can prepare us for real experiments or help us develop ideas about an experiment that is impossible to perform.

In this thought experiment you read a short fictional play about how an argument between philosophers with opposing viewpoints may have transpired. In the play you saw how the philosophers had different theories about what the world is made of, and each brought up different points to back up his own theory. You saw how they had a back and forth discussion that was sometimes heated.

You may have noticed that the framework you learned from the play helped you form the hypothetical argument for a new theory about how light and matter interact. Practicing thought experiments can help you frame your own arguments and can help you become clearer about your ideas and how to express them to others in an understandable way.

Scientists use thought experiments as a way of thinking deeply about ideas. If their ideas lead to an actual experiment, they think about what the experiment might be expected to show or prove, how a physical experiment might be set up, what steps must be followed in performing the experiment, and what outcomes might occur. It is important in planning an experiment to think about as many factors involved as possible before beginning. When the experiment has been completed, the scientists will review the results to see if the expected outcome happened or if something else occurred. They might ask what would happen if some part of the experiment were changed. Would they get a different result? If they get unexpected results, they might look back at the experiment to see if all the steps were performed correctly, or they might realize they have made a new discovery.

V. Just For Fun

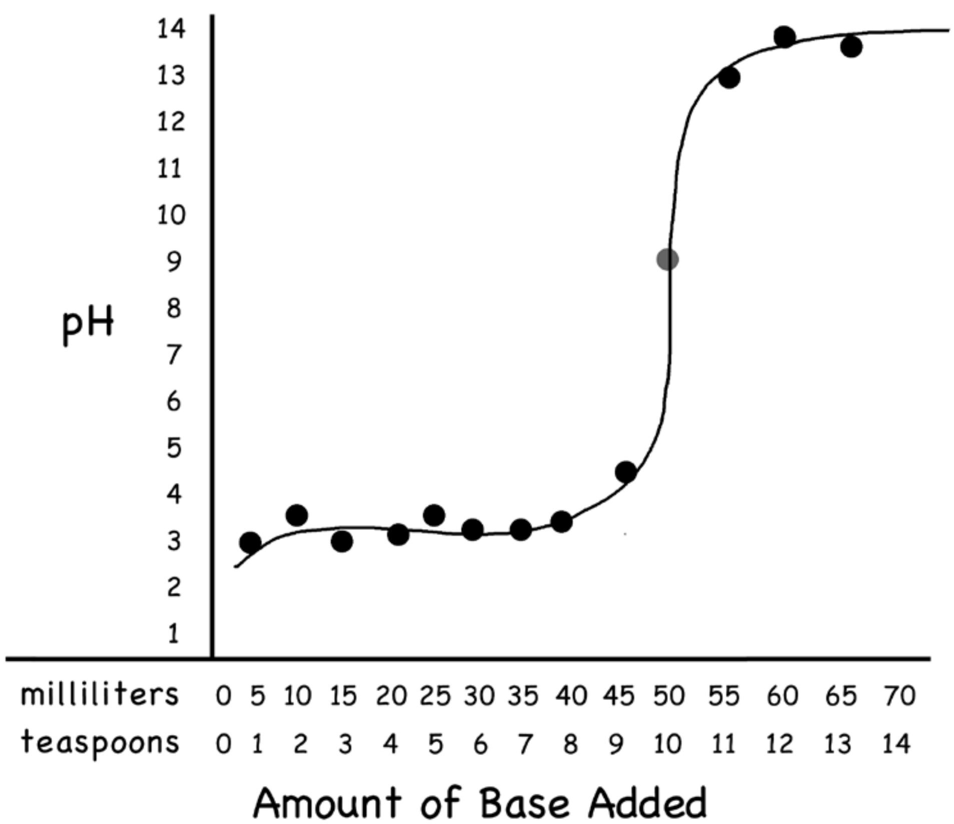
Imagine you are on a strange new planet. It has elements, just like planet Earth, and you discover everything seems to be made of candy.

List the experiments you might perform to prove or disprove your hypothesis that everything is made of candy.

Testing a Candy Planet

Experiment 7

Vinegar and Ammonia in the Balance: An Introduction to Titration



Introduction

Do you think you can tell when an acid is neutralized by a base?

I. Think About It

❶ Do you think it can be important to know the concentration of an acid or a base? Why or why not?

❷ What do you think happens when equal concentrations of an acid and a base are mixed together? Why?

❸ If you mixed an acid into a base a little at a time, do you think you could tell whether the solution went from being more acidic to more basic? Why or why not?

❹ What kinds of data do you think you could plot on a graph? Why?

❺ What kinds of data do you think you could not plot on a graph? Why?

❻ Do you think making a graph of data could be helpful? Why or why not?

II. Experiment 7: Vinegar and Ammonia in the Balance: An Introduction to Titration

Date __________

Objective ______________________________

____

Hypothesis ______________________________

____

____

Materials

red cabbage indicator (from Experiment 6)
household ammonia
vinegar
large glass jar
measuring spoons
measuring cup

EXPERIMENT

1. Measure 60 ml (1/4 cup) of vinegar and put it in the glass jar.
2. Add enough of the red cabbage indicator to get a deep red color.
3. Carefully add 5 ml (1 tsp.) of ammonia to the vinegar solution. Swirl gently, and record the color of the solution in the chart on the following page.
4. Add another 5 ml (1 tsp.) of ammonia to the vinegar solution, swirl the solution, and record the color.
5. Keep adding ammonia to the vinegar solution 5 ml (1 tsp.) at a time. Record the color of the solution each time along with the total amount of ammonia that has been added.
6. When the color has changed from red to green, add a few more ml (tsp.) of ammonia to see what happens.

Results

Number of ml (tsp) of ammonia	Color of solution
5 ml (1 tsp)	red
10 ml (2 tsp)	red

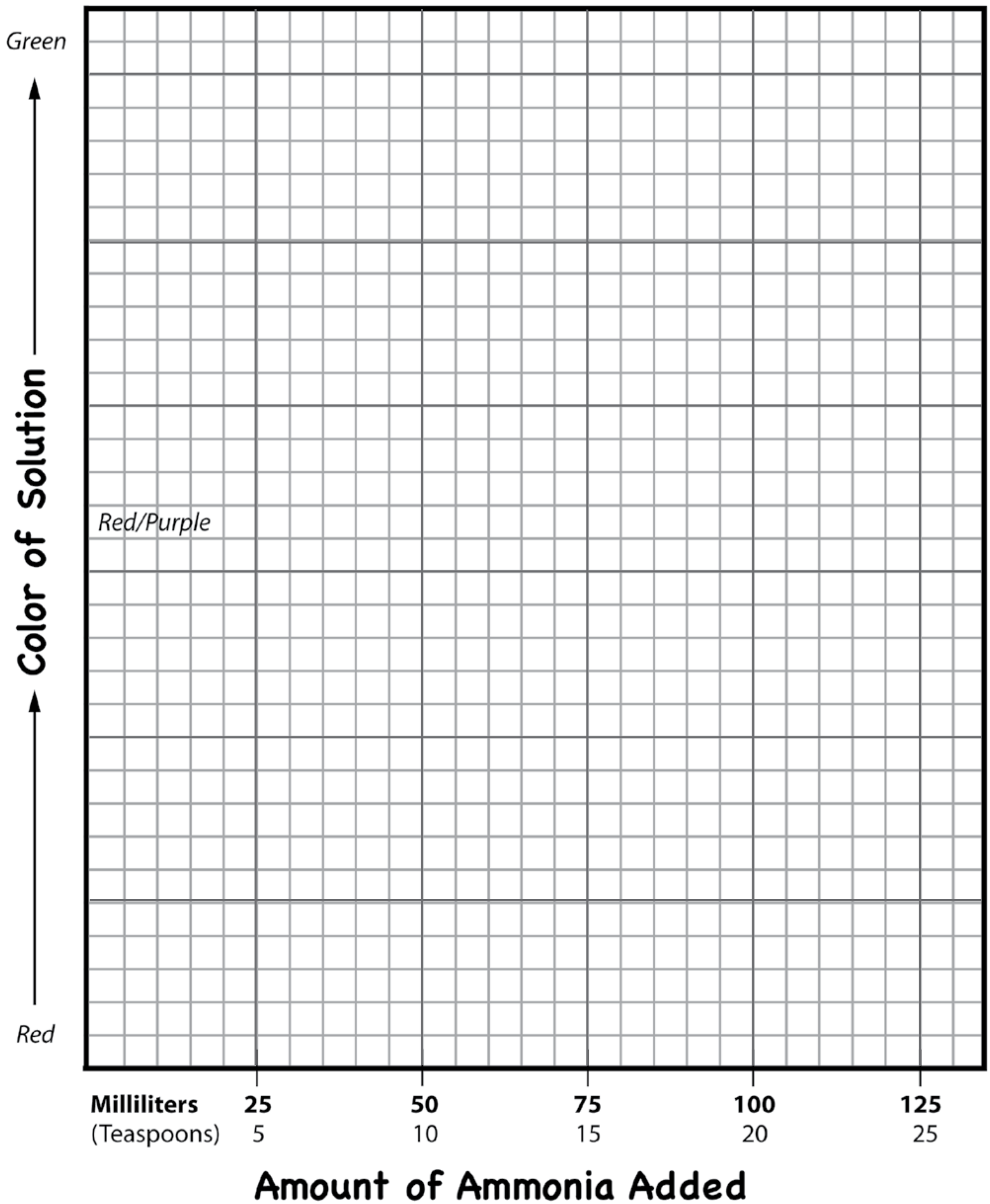
Number of ml (tsp.) of Ammonia [continued]	Color of Solution [continued]

❶ Plot the data from your chart using the graph on the next page. The horizontal axis is labeled **Amount of Ammonia Added**, and the vertical axis is labeled **Color of Solution**.

❷ For every 5 ml (1 tsp.) of ammonia added, mark the graph with a round dot corresponding to the color of the solution.

❸ When all of the data have been plotted, connect the dots.

Graphing Your Data



III. Conclusions

What conclusions can you draw from your observations?

IV. Why?

A titration is a technique in which one substance is added to another substance in small quantities. By adding the second substance in small quantities, any subtle change in the properties of the solution can be observed. The technique of titration is used not only for acid-base reactions but also for other types of reactions.

The concentration of something is simply the number of molecules in a given volume. A bottle of concentrated hand soap, for example, has more soap molecules (or less water) in it than one that is not concentrated. Because it is more concentrated, it takes less soap to make a lather than a less concentrated product, but it is still the same soap.

The same is true for acids and bases. If a solution is concentrated, it has more of the molecules that make it either acidic or basic. Therefore, it is stronger. This is illustrated with the difference between glacial acetic acid (concentrated acetic acid) and vinegar (dilute acetic acid). Glacial acetic acid has a very pungent odor and will burn skin on contact. Vinegar is the same acid, but much less concentrated and is safe to eat.

A neutral solution is one that is neither acidic nor basic. Acids and bases neutralize each other to make a salt and water. *Salt* refers to a product of an acid-base reaction rather than table salt.

For an acid-base reaction, the unknown concentration of an acid or base can be determined by doing a titration. How does this work? If you start with an acid solution and add a base, the base will neutralize the acid. Once all of the acid has been neutralized, the next drop of base will cause the pH to change dramatically. If the concentration of one solution (acid or base) is known, then the concentration of the other, unknown solution can be determined.

The neutralization process of acids and bases is used in everyday life. For example, antacids are bases that are used to neutralize hydrochloric acid in the stomach when someone has acid indigestion.

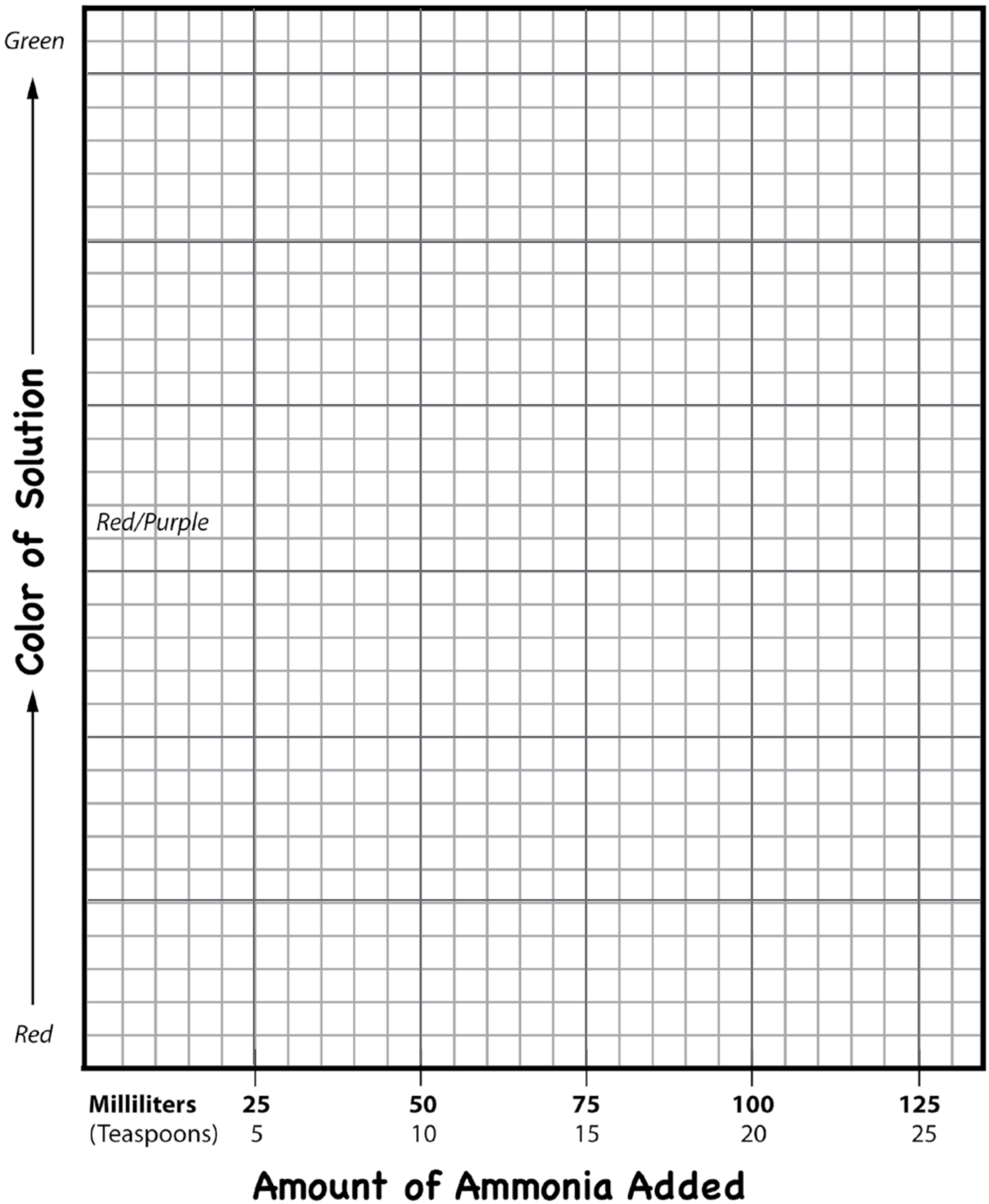
V. Just For Fun

Find some household solutions that you think may be an acid or a base. Test them with the red cabbage juice indicator. Choose one acid and one base and do a titration, following the steps of the previous experiment. Charts are provided for recording your data and plotting your graph.

Acid ______	
Base ______	
Number of ml (tsp.) of base added	**Color of solution**

Number of ml (tsp.) of base added	Color of solution

Graphing Your Data

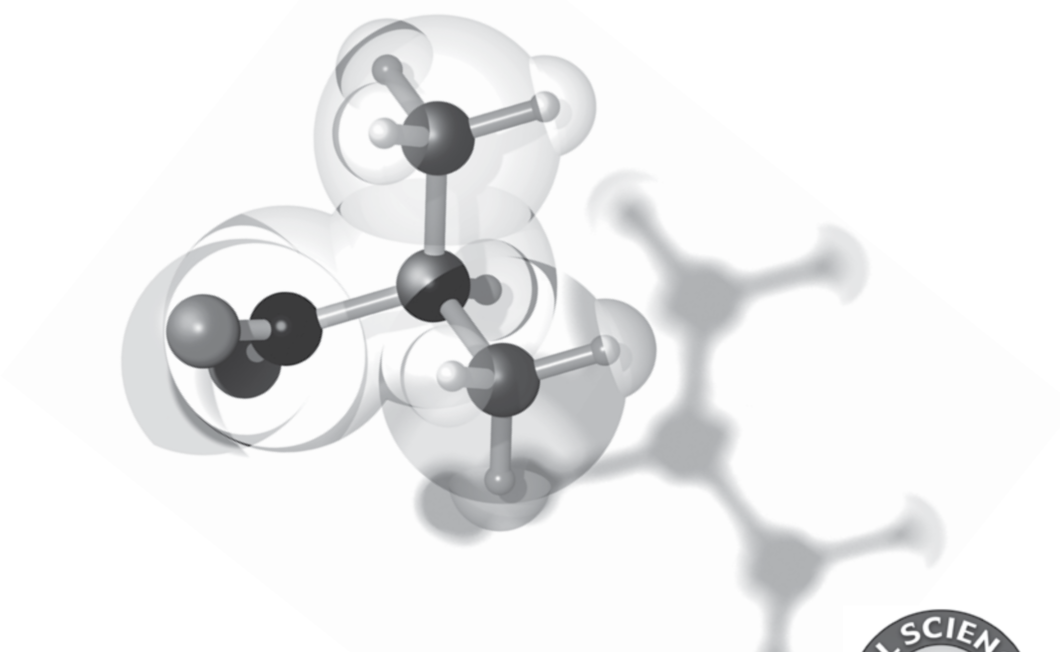


Grades 5-8

Focus On Middle School Chemistry

Teacher's Manual

3rd Edition



Rebecca W. Keller, PhD

Real Science-4-Kids

Real Science-4-Kids

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A Note from the Author

This curriculum is designed to engage middle school level students in further exploration of the scientific discipline of chemistry. The *Focus On Middle School Chemistry Student Textbook—3rd Edition* and the accompanying *Laboratory Notebook* together provide students with basic science concepts needed for developing a solid framework for real science investigation into chemistry.

The experiments in the *Laboratory Notebook* allow students to expand on concepts presented in the *Student Textbook* and develop the skills needed for using the scientific method. This *Teacher's Manual* will help you guide students through the laboratory experiments.

There are several sections in each chapter of the *Laboratory Notebook*. The section called *Think About It* provides questions to help students develop critical thinking skills and spark their imagination. The *Experiment* section provides students with a framework to explore concepts presented in the *Student Textbook*. In the *Conclusions* section students draw conclusions from the observations they have made during the experiment. A section called *Why?* provides a short explanation of what students may or may not have observed. And finally, in each chapter an additional experiment is presented in *Just For Fun*.

The experiments take up to 1 hour. Materials needed for each experiment are listed on the following pages and also at the beginning of each experiment.

Enjoy!

Rebecca W. Keller, PhD

Materials at a Glance

Experiment 1	Experiment 3	Experiment 5	Experiment 6	Experiment 7
imagination **Experiment 2** 10 ml glass graduated cylinder glass eyedropper 60 ml (1/4 cup) water 60 ml (1/4 cup) rubbing alcohol 60 ml (1/4 cup) vegetable oil waterproofing substance, e.g., wax, Scotch-Gard additional water and vegetable oil (small amount) **Optional** disposable glass tube Goo Gone or similar cleaner	food labels, several periodic table of elements from *Student Textbook* resources (books or online) **Optional** computer with internet access **Experiment 4** colored marshmallows, 1 pkg small, 1 pkg large (or gumdrops and/or jellybeans) toothpicks, 1 box marking pen **Optional** food coloring	baking soda lemon juice balsamic vinegar salt and water: 15-30 ml salt dissolved in 120 ml water (1-2 tbsp. salt dissolved in 1/2 cup of water) 2 or more egg whites milk small jars, 7 or more measuring cups and spoons eye dropper Peanut Brittle (see next page–Foods) pan, buttered saucepan	one head of red cabbage distilled water, about 1 liter (1 quart) various solutions, such as: ammonia vinegar clear soda pop milk mineral water large saucepan knife several small jars white coffee filters eyedropper measuring cup measuring spoons marking pen scissors ruler suggested natural materials (see next page)	red cabbage juice indicator (from Experiment 6) household ammonia vinegar large glass jar measuring spoons measuring cup household solutions chosen by students (to test for acidity and basicity)

Experiment 8	Experiment 9	Experiment 10	Experiment 11	Experiment 12
tincture of iodine [Iodine is VERY poisonous — DO NOT LET STUDENTS EAT any food items with iodine on them.] a variety of raw foods, including: pasta bread celery potato banana (ripe) and other fruits 1 unripe (green) banana liquid laundry starch (or equal parts borax and corn starch mixed in water) absorbent white paper eye dropper cookie sheet marking pen knife	about 120 ml (1/2 cup) each: water ammonia vegetable oil rubbing alcohol melted butter vinegar small jars (7 or more) food coloring (6 colors) dish soap, 30 ml (2 tbsp.) eyedropper measuring cup measuring spoons marking pen spoon ballpoint ink pens of various colors, including black (see bottom of next page)* rubbing alcohol coffee filters, several (white) cardboard shoebox (or similar size box) tape scissors ruler	1-2 brown paper bags cut into about 20 5 cm x 5 cm (2″x 2″) squares wax paper, 8 pieces paper towels tape knife scissors ruler marker or pen foods: vegetable oil butter celery potatoes banana avocado lard margarine water orange cheese milk cream several food products labeled fat free and low fat	liquid laundry starch, 120 ml (1/2 cup); or 10 ml (2 tsp.) borax and 10 ml (2 tsp.) cornstarch Elmer's white glue, 60 ml (1/4 cup) Elmer's blue glue (or another different glue), 60 ml (1/4 cup) water 2 small jars marking pen that will write on glass Popsicle sticks for stirring measuring cup safety goggles rubber gloves apron 10 ml graduated cylinder beaker or glass jar glass stirring rod Nylon Synthesis and Rope Trick Kit from Home Science Tools**	tincture of iodine [VERY POISONOUS— DO NOT LET STUDENTS EAT] bread (1-2 slices) timer wax paper marking pen cup one raw egg one raw onion table salt clear liquid dish washing detergent rubbing alcohol (isopropanol, 70-90%) wooden stir stick or Q-tip coffee filter (any color) sieve 2 glass jars or large test tubes measuring cup and measuring spoons blender

**Nylon Synthesis and Rope Trick Kit from Home Science Tools: http://www.hometrainingtools.com/, Item # KT-ISNYLON

Materials

Quantities Needed for All Experiments

Equipment

apron
beaker or glass jar
blender
cookie sheet
cup
eyedropper
eyedropper, glass
gloves, rubber
goggles, safety
graduated cylinder, glass, 10 ml
jar, glass, 2, or large test tubes
jar, large glass
jar, small, 7 or more
knife
measuring cups
measuring spoons
pan
rod, glass stirring
ruler
saucepan, large
scissors
sieve
spoon
timer

Optional

computer with internet access

Other

natural materials, (suggested) Exper. 6:
  poppyseed or cornflower petals; madder plant (Rubiaceae family); red beets; rose petals; berries; blue and red grapes; cherries; geranium petals; morning glory; red onion; petunia petals; hibiscus petals (or hibiscus tea); carrots; other strongly colored plant materials of students' choice
periodic table of elements from *Student Textbook*
resources (books or online)

Materials

alcohol, rubbing (isopropanol, 70-90%), at least 180 ml (3/4 cup)
ammonia, household
coffee filter (any color)
coffee filter, white, several
dish soap
dish washing detergent, liquid, clear
food coloring (6 colors)
glue, Elmer's blue (or another glue different from white), 60 ml (1/4 cup)
glue, Elmer's white, 60 ml (1/4 cup)
iodine, tincture of [VERY poisonous: DO NOT LET STUDENTS EAT any food items with iodine on them]
labels, food (student chosen), several
Nylon Synthesis and Rope Trick Kit from Home Science Tools: http://www.hometrainingtools.com/ Item # KT-ISNYLON
paper, absorbent white
paper bag, brown, 1-2
paper towels
pen, marking
pen, marking, that will write on glass
pens, ballpoint ink of various colors, including black (see below)*
Popsicle sticks for stirring
shoebox, cardboard (or similar size box)
solutions, household, chosen by students (to test for acidity and basicity)
starch, liquid laundry (or equal parts borax and corn starch mixed in water)
stick, wooden stir stick or Q-tip
tape
toothpicks, 1 box
water, distilled, about 1 liter (1 quart)
waterproofing substance, such as car wax, floor wax, silicone spray, or Scotch-Gard (small amount
wax paper

Optional

Goo Gone or similar cleaner
tube, glass, disposable

Foods

baking soda
banana, 2 unripe (green)
bread (1-2 slices)
butter, about 120 ml (1/2 cup)
cabbage, red, 1 head
cheese
cream
egg, one raw
egg whites, 2 or more
fat free food products, several
lard
lemon juice
margarine
marshmallows, colored, 1 pkg small, 1 pkg large (or gumdrops and/or jellybeans)
milk
mineral water
onion, one raw
peanut brittle ingredients
  360 ml (1 1/2 cups) sugar
  240 ml (1 cup) white corn syrup
  120 ml (1/2 cup) water
  360 ml (1 1/2 cups) raw peanuts (can be omitted)
  5 ml (1 teaspoon) baking soda
  butter to grease pan
raw foods, including:
  avocado
  banana (ripe) and other fruits
  bread
  celery
  orange
  pasta
  potato
salt, 15-30 ml (1-2 tbsp.) or more
soda pop, clear
vegetable oil, about 180 ml (3/4 cup)
vinegar
vinegar, balsamic
water

* Experiment 9—Pens: Regular Bic® or other brand ballpoint pens can be used in this experiment. Black, blue, red, and green will give enough colors to compare. Also, multicolored ballpoint pens work well. Try to find one with at least 7 or 8 different colors. Ballpoint pens work better than felt tip pens or markers. Buy inexpensive pens for this experiment because they will be taken apart.

Contents

Experiment 1

Learning to Argue Scientifically

Materials Needed

- imagination

Objectives

In this experiment students will explore thought experiments and presenting scientific arguments.

The objectives of this lesson are for students to:

- Explore thought experiments.
- Explore the development of scientific arguments.

Experiment

I. Think About It

Read this section of the *Laboratory Notebook* with your students.

Ask questions such as the following to guide open inquiry.

- *Do you think it is important for scientists to have arguments about their theories? Why or why not?*
- *Do you think arguing helps scientists better understand science? Why or why not?*
- *Do you think it is helpful for scientists to practice arguing? Why or why not?*
- *Do you think an experiment can be performed by thinking about it? Why or why not?*
- *What do you think a scientist needs to think about before performing an experiment?*
- *What do you think a scientist might need to think about after an experiment has been completed?*

II. Experiment 1: Learning to Argue Scientifically—A Thought Experiment

A thought experiment is done by thinking scientifically about how something might work without actually doing an experiment. In this experiment students will read a fictional play to gain an understanding of how scientists argue their theories, and they will begin to learn how to form the basis of a scientific argument by thinking about it.

Have the students read the entire experiment.

Objective: An objective is provided.
Hypothesis: A hypothesis is provided.

EXPERIMENT

❶ Have the students read the play *The Mystery of Substance: A Philosophical Play* by D. R. Megill.

❷-❹ Have the students answer the questions about the play. There are no "right" answers.

Results

❶-❷ Have the students answer the questions based on what they learned from the play. There are no "right" answers.

III. Conclusions

Have the students use their observations to draw conclusions about arguing scientifically.

IV. Why?

Read this section of the *Laboratory Notebook* with your students.
Discuss any questions that might come up.

V. Just For Fun

Students are to imagine they are on a newly discovered planet that appears to be made entirely of candy. They are to think of experiments to do to prove or disprove this theory. There are no right answers to this thought experiment.

Experiment 7

Vinegar and Ammonia in the Balance: An Introduction to Titration

Materials Needed

- red cabbage juice indicator (from Experiment 6)
- household ammonia
- vinegar
- large glass jar
- measuring spoons
- measuring cup
- household solutions chosen by students (to test for acidity and basicity)

Objectives

In this experiment students will explore acid-base reactions by performing a titration.

The objectives of this lesson are for students to:

- Perform a titration.
- Plot and analyze data on a graph.

Experiment

I. Think About It

Read this section of the *Laboratory Notebook* with your students.

Ask questions such as the following to guide open inquiry.

- *What do you think happens when you mix an acid and a base together? Why?*
- *What products do you think you would get by mixing an acid and a base together?*
- *Do you think knowing the concentration of an acid or a base could be helpful? Why or why not?*
- *Do you think there are times when you would want to have a solution that is neutral? Why or why not?*
- *Do you think plotting data on a graph can be useful? Why or why not?*

II. Experiment 7: Vinegar and Ammonia in the Balance: An Introduction to Titration

Have the students read the entire experiment before writing an objective and a hypothesis.

Objective: Have the students write an objective (What will they be learning?). For example:

- *To determine how much ammonia is needed to change the color of red cabbage juice indicator in vinegar from red to green*

Hypothesis: Have the students write a hypothesis. For example:

- *An indicator can be used to observe the acid-base reaction of vinegar and ammonia.*

EXPERIMENT

In this experiment, students will perform an acid-base titration using a red cabbage juice indicator. The red cabbage juice indicator from Experiment 6 is required. If the indicator is too old (more than two weeks or has mold or bacteria growing in it), have the students make fresh cabbage indicator.

NOTE: This titration can be tricky if the concentration of the base is too dilute.

A quick test can be performed by the teacher without the students' observation. Take 60 ml (1/4 cup) of vinegar and add indicator to it. See that it turns red. Add 60 ml (1/4 cup) ammonia directly to this acid-indicator mixture. The color should turn green, but if the color is still red, add another 60 ml (1/4 cup) of ammonia. It should turn green; however, if it does not, dilute the vinegar with 120 ml (1/2 cup) water and repeat the above steps.

This quick "titration" will help determine how much total ammonia is needed to neutralize the acid. Adjust the titration so that not much more than 60 ml (1/4 cup) of ammonia is needed. Less is all right, but the students will get frustrated if they have to add more than 100 ml (20 teaspoons) of ammonia, and the best part of the titration is the last part when they see the color change occur.

❶-❷ Have the students measure 60 ml (1/4 cup) of vinegar into a jar and add enough red cabbage juice to get a deep red color.

❸-❻ Students will add ammonia to the vinegar 5 ml (1 tsp.) at a time. Each time the students add ammonia, they will swirl the solution and then record the color of the solution and the total amount of ammonia that has been added. There is a chart provided in the *Results* section.

As the students add ammonia, the color stays mostly red, then turns a little purple, and finally turns all green. The transition is quite striking. Have the students continue adding ammonia to see that the color stays green.

Graphing Your Data

❶-❸ Have the students take the data from their chart and plot it on the graph provided. When all the data has been plotted, have them connect the data points.

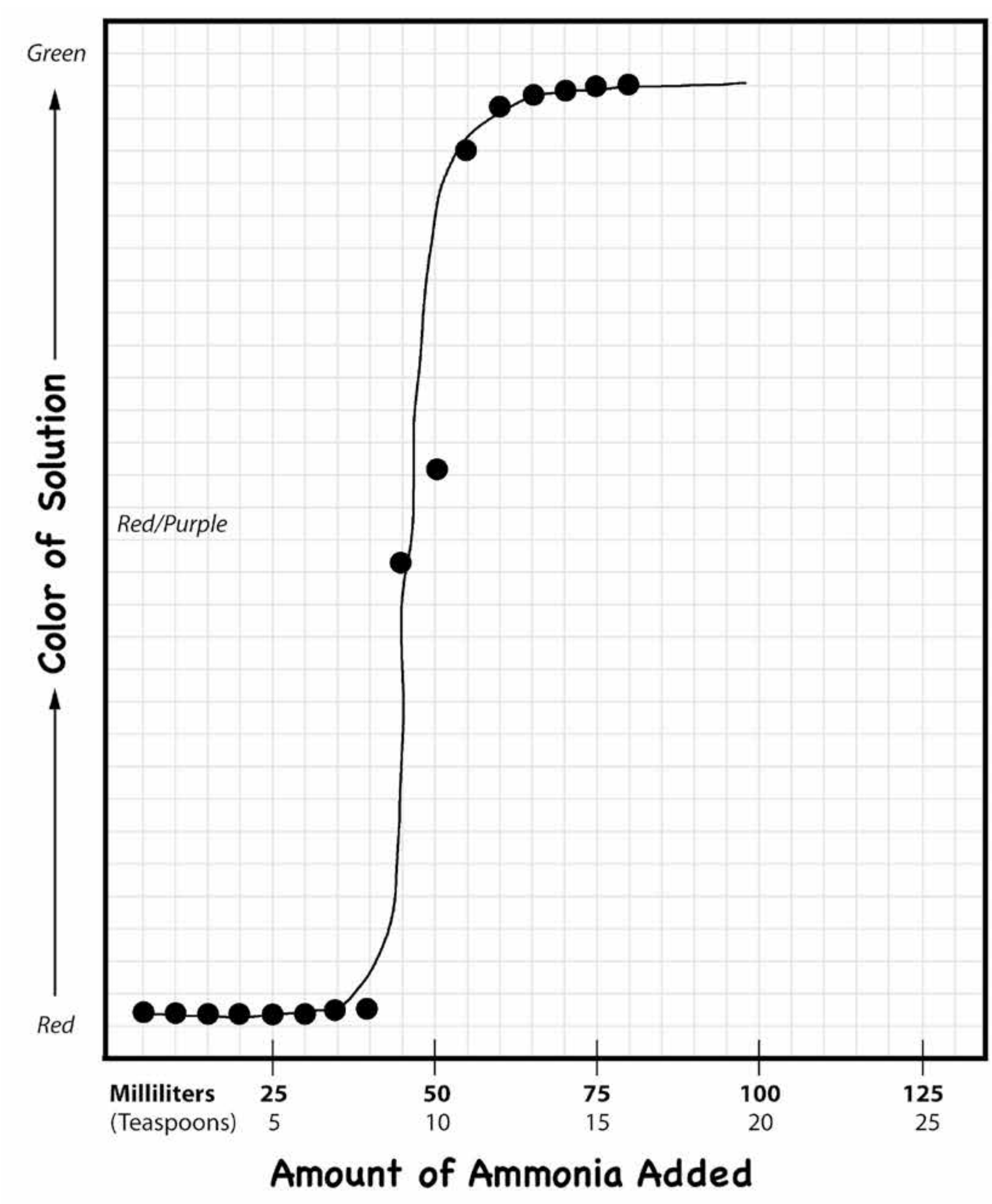
The data points should look something like those shown in the following graph. Many points lie along the bottom left of the plot, then one or two points will be in the middle. Finally, several will be along the top right-hand side of the plot.

Have the students connect the points with a smooth curved line. Their plot should look similar to the following. Discuss the following parts of the graph:

- In the left-hand lower portion of the plot, the solution is acidic.
- In the middle portion, where the line is going upward, the solution is between acidic and basic (near neutral).
- In the upper right-hand corner, the solution is basic.

Point out that we know this because the color of the indicator is known at various pH values, as we observed in Experiment 6.

Example *(Answers may vary.)*



III. Conclusions

Have the students review the results they recorded for the experiment. Have them draw conclusions based on the data they collected.

Have the students write down the amount of ammonia it took to neutralize the vinegar. Note whether this equals the amount of vinegar that was used—60 ml (1/4 cup [12 tsp.]). Depending on the brands of vinegar and ammonia used, the amounts are often equal.

Help them reach valid conclusions. Some examples:

- *It took 55 ml of ammonia to turn the solution green.*
- *It took 11 teaspoons to neutralize the vinegar with ammonia.*
- *The amount of ammonia required to neutralize the vinegar was equal to the amount of vinegar used.*

IV. Why?

Read this section of the *Laboratory Notebook* with your students.
Discuss any questions that might come up.

V. Just For Fun

Students are to repeat the experiment with a different acid and base.

Help the students find household solutions that they think may be acidic or basic. Have them use red cabbage juice indicator to test each solution and then select one acid and one base. Have the students follow the steps of the previous experiment to do a titration.

Some possible acid/base combinations to test:

- Clear soda pop (acid) and baking soda water (base).
- Clear soda pop (acid) and ammonia (base).
- Dilute clear window cleaner (base) with an acid like vinegar or clear soda pop.
- Lye [sodium hydroxide] (base) with an acid like vinegar or clear soda pop.
  (Lye is caustic—adult supervision is required.)

A chart is provided for the collection of data and a graph for plotting the data.

Focus On

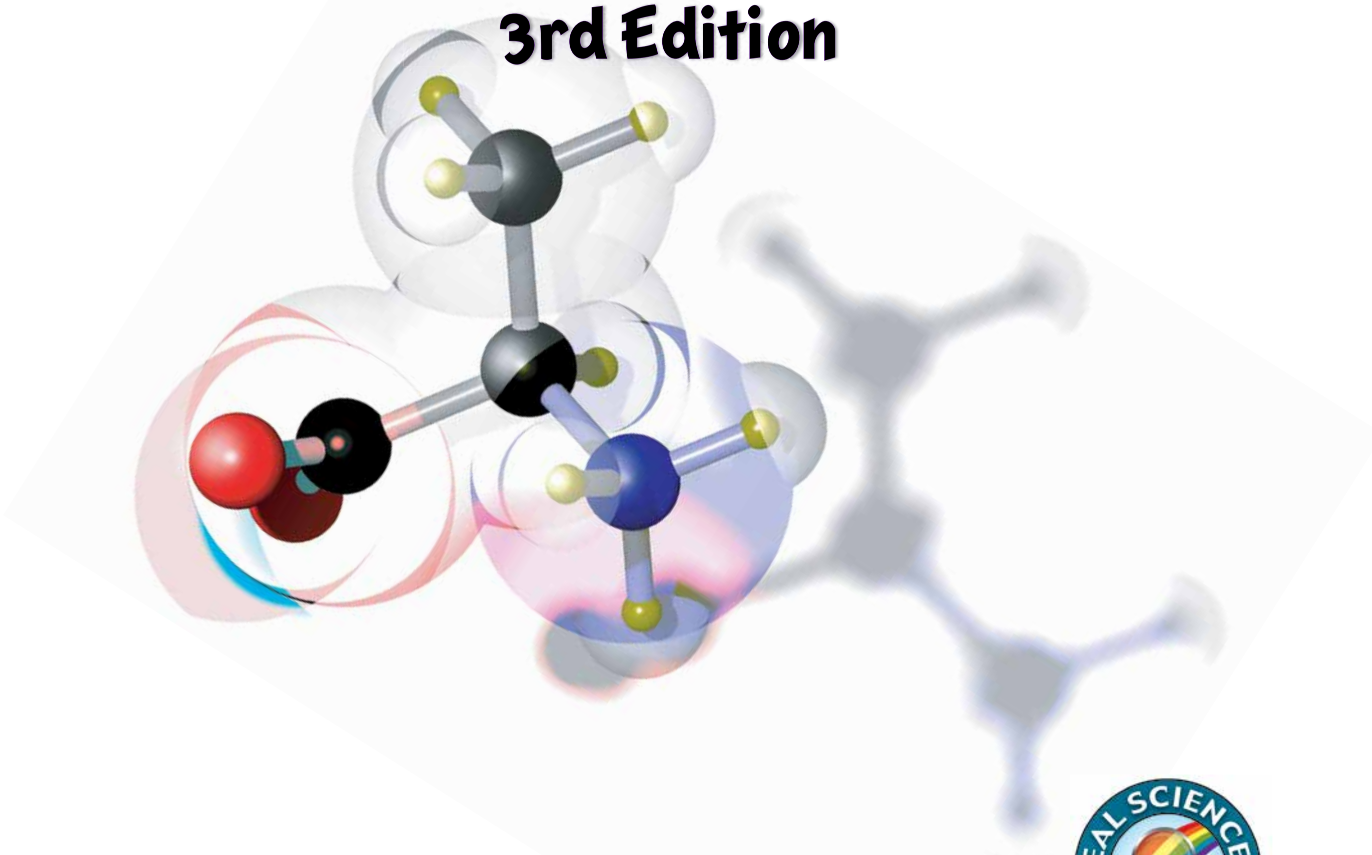
Grades 5-8

Middle School

Chemistry

Lesson Plan

3rd Edition



Rebecca W. Keller, PhD

Real Science-4-Kids

Focus On Middle School Chemistry Lesson Plan—3rd Edition

Published by Gravitas Publications Inc.
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www.realscience4kids.com

LESSON PLAN INSTRUCTIONS

This *Lesson Plan* accompanies *Focus On Middle School Chemistry Student Textbook*, *Laboratory Notebook,* and *Teacher's Manual—3rd Edition*. It is designed to be flexible to accommodate a varying schedule as you go through the year's study. And it makes it easy to chart weekly study sessions and create a portfolio of your student's yearlong performance. The PDF format allows you to print pages as you need them.

This Lesson Plan file includes:

- Weekly Sheets
- Self-Review Sheet
- Self-Test Sheet
- Sticker Templates

Materials recommended but not included:

- 3-ring binder
- Indexing dividers (3)
- Labels—24 per sheet,1.5" x 1.5" (Avery 22805)

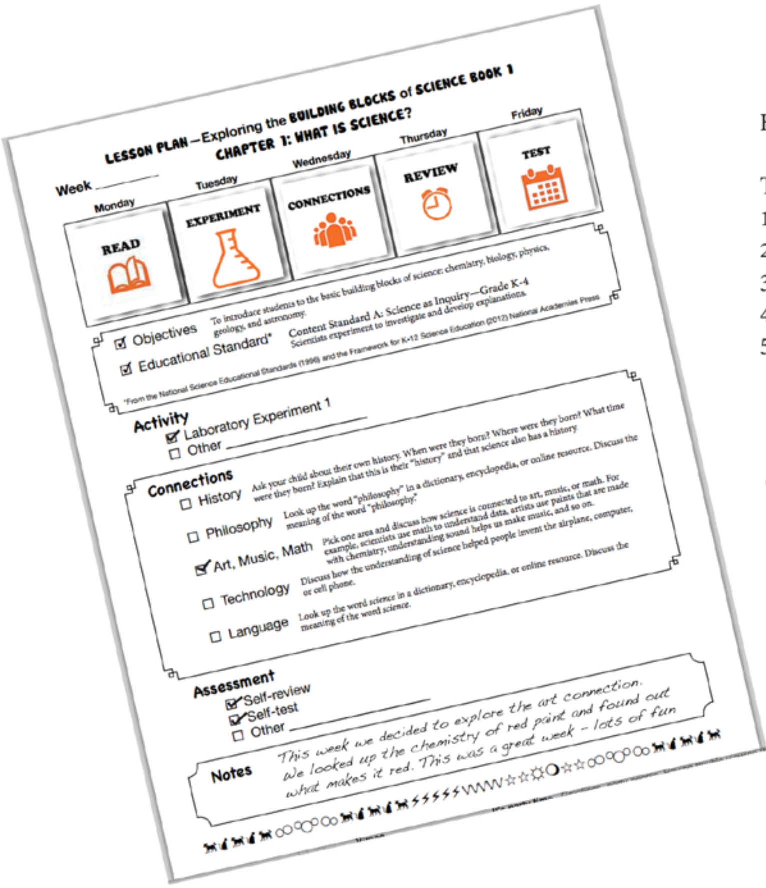
Use the Weekly Sheets to map out daily activities and keep track of student progress. For each week you decide when to read the text, do the experiment, explore the optional connections, review the text, and administer tests. For those families and schools needing to provide records of student performance and show compliance to standards, there is a section on the Weekly Sheets that shows how the content aligns to the National Science Standards.

To use this Lesson Plan:

- Print the Weekly Sheets
- Print Self-Review Sheets
- Print Self-Test Sheets
- Print the stickers on 1.5" x 1.5" labels
- Place all the printed sheets in a three-ring binder separated by index dividers

At the beginning of each week, use the squares under each weekday to plan your daily activities. You can attach printed stickers to the appropriate boxes or write in the daily activities. At the end of the week, use the Notes section to record student progress and performance for that week.

WEEKLY LESSON PLAN SAMPLES



LESSON PLAN — Exploring the BUILDING BLOCKS of SCIENCE BOOK 1
CHAPTER 1: WHAT IS SCIENCE?

Week

Monday	Tuesday	Wednesday	Thursday	Friday
READ	EXPERIMENT	CONNECTIONS	REVIEW	TEST

☑ Objectives — To introduce students to the basic building blocks of science: chemistry, biology, physics, geology, and astronomy.

☑ Educational Standard* — Content Standard A: Science as Inquiry—Grade K-4. Scientists experiment to investigate and develop explanations.

*From the National Science Educational Standards (1996) and the Framework for K-12 Science Education (2012) National Academies Press

Activity
☑ Laboratory Experiment 1
☐ Other

Connections
☐ History — Ask your child about their own history. When were they born? Where were they born? What time were they born? Explain that this is their "history" and that science also has a history.
☐ Philosophy — Look up the word "philosophy" in a dictionary, encyclopedia, or online resource. Discuss the meaning of the word "philosophy."
☑ Art, Music, Math — Pick one area and discuss how science is connected to art, music, or math. For example, scientists use math to understand data, artists use paints that are made with chemistry, understanding sound helps us make music, and so on.
☐ Technology — Discuss how the understanding of science helped people invent the airplane, computer, or cell phone.
☐ Language — Look up the word science in a dictionary, encyclopedia, or online resource. Discuss the meaning of the word science.

Assessment
☑ Self-review
☑ Self-test
☐ Other

Notes This week we decided to explore the art connection. We looked up the chemistry of red paint and found out what makes it red. This was a great week – lots of fun

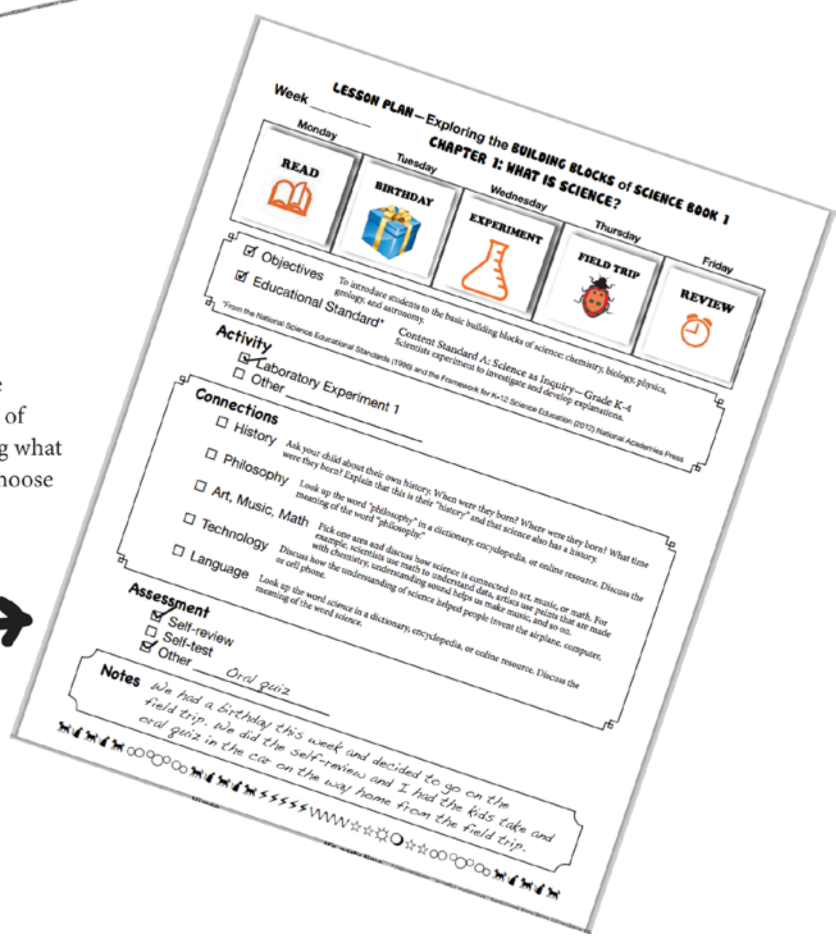
Here is a sample of a normal week.

The recommended sequence is
1 - Read the student textbook on the first day.
2 - Do the laboratory experiment on the second day.
3 - Pick one or more connections to explore on the third day.
4 - Do the self-review sheet on the fourth day.
5 - Administer the self-test or another exam on the fifth day.

Here is a sample of a week with other activities

1- Find at least one day to READ the text.
2 - Find a day to perform the EXPERIMENT.
3 - Find a day to do the REVIEW or TEST.

Any activity that is missed can be rescheduled for the following week. However, keep to the main sequence of reading the text, doing the experiment, and reviewing what has been covered. If an activity needs to be missed, choose the CONNECTIONS or SELF-TEST.



LESSON PLAN — Exploring the BUILDING BLOCKS of SCIENCE BOOK 1
CHAPTER 1: WHAT IS SCIENCE?

Week

Monday	Tuesday	Wednesday	Thursday	Friday
READ	BIRTHDAY	EXPERIMENT	FIELD TRIP	REVIEW

☑ Objectives — To introduce students to the basic building blocks of science: chemistry, biology, physics, geology, and astronomy.

☑ Educational Standard* — Content Standard A: Science as Inquiry—Grade K-4. Scientists experiment to investigate and develop explanations.

*From the National Science Educational Standards (1996) and the Framework for K-12 Science Education (2012) National Academies Press

Activity
☑ Laboratory Experiment 1
☐ Other

Connections
☐ History — Ask your child about their own history. When were they born? Where were they born? What time were they born? Explain that this is their "history" and that science also has a history.
☐ Philosophy — Look up the word "philosophy" in a dictionary, encyclopedia, or online resource. Discuss the meaning of the word "philosophy."
☐ Art, Music, Math — Pick one area and discuss how science is connected to art, music, or math. For example, scientists use math to understand data, artists use paints that are made with chemistry, understanding sound helps us make music, and so on.
☐ Technology — Discuss how the understanding of science helped people invent the airplane, computer, or cell phone.
☐ Language — Look up the word science in a dictionary, encyclopedia, or online resource. Discuss the meaning of the word science.

Assessment
☑ Self-review
☐ Self-test
☑ Other Oral quiz

Notes We had a birthday this week and decided to go on the field trip. We did the self-review and I had the kids take and oral quiz in the car on the way home from the field trip.

Week __________

CHAPTER 1: WHAT IS CHEMISTRY?

Monday	Tuesday	Wednesday	Thursday	Friday

☑ Objectives To have students explore the history of our understanding of matter.

☑ Educational Standard* **Content Standard 5-PS1-2**
Science assumes consistent patterns in natural systems.

*From the Next Generation Science Standards (NGSS)

Activity

- ☐ Laboratory Experiment 1
- ☐ Other ______________________

Connections

- ☐ History Look up alchemy and explore how alchemists contributed to the history of chemistry.
- ☐ Philosophy Look up the philosopher Anaximander and explore how his ideas contributed to our understanding of chemistry.
- ☐ Art, Music, Math Explore how chemistry has played a role in creating modern paint and materials for creating sculptures.
- ☐ Technology Discuss how chemistry has contributed to new materials (e.g., nylon, polyester, etc.) and how this has changed the way we live.
- ☐ Language Look up the word *chemistry* in a dictionary or encyclopedia and discuss its meaning.

Assessment

- ☐ Self-review
- ☐ Self-test
- ☐ Other ______________________

Notes

Week __________ **CHAPTER 7: ACID-BASE NEUTRALIZATION**

Monday	Tuesday	Wednesday	Thursday	Friday

☑ Objectives To examine acid-base chemistry.

☑ Educational Standard* **Content Standard 3-5ETS-2**
Engineers improve existing technologies and develop new ones.

*From the Next Generation Science Standards (NGSS)

Activity

☐ Laboratory Experiment 7
☐ Other ______________________

Connections

☐ History Discuss how the first titrations were used to standardize solutions (such as indigo).

☐ Philosophy Discuss why standardizations are needed not only for chemistry but for other areas like commerce, finance, and civil laws.

☐ Art, Music, Math Explore how mathematics is used to calculate the concentration of an unknown base or acid.

☐ Technology Discuss how the pH meter helps make titrations more accurate.

☐ Language Look up the word *titration* in a dictionary or encyclopedia and discuss its meaning.

Assessment

☐ Self-review
☐ Self-test
☐ Other ______________________

Notes

SELF-REVIEW

Think about all of the ideas, concepts, and facts you read about in this chapter. In the space below, write down everything you've learned.

Date ________________ Chapter ____

SELF-TEST

Imagine you are the teacher and you are giving your students an exam. In the space below, write 5 questions you would ask a student based on the information you learned in this chapter.

Date ________________ Chapter ____

READ READ READ READ

REVIEW REVIEW REVIEW REVIEW

EXPERIMENT EXPERIMENT EXPERIMENT EXPERIMENT

CONNECTIONS CONNECTIONS CONNECTIONS CONNECTIONS

TEST TEST TEST TEST

READ READ READ READ

HOLIDAY

HOLIDAY

HOLIDAY

HOLIDAY

FIELD TRIP

FIELD TRIP

FIELD TRIP

FIELD TRIP

BIRTHDAY

BIRTHDAY

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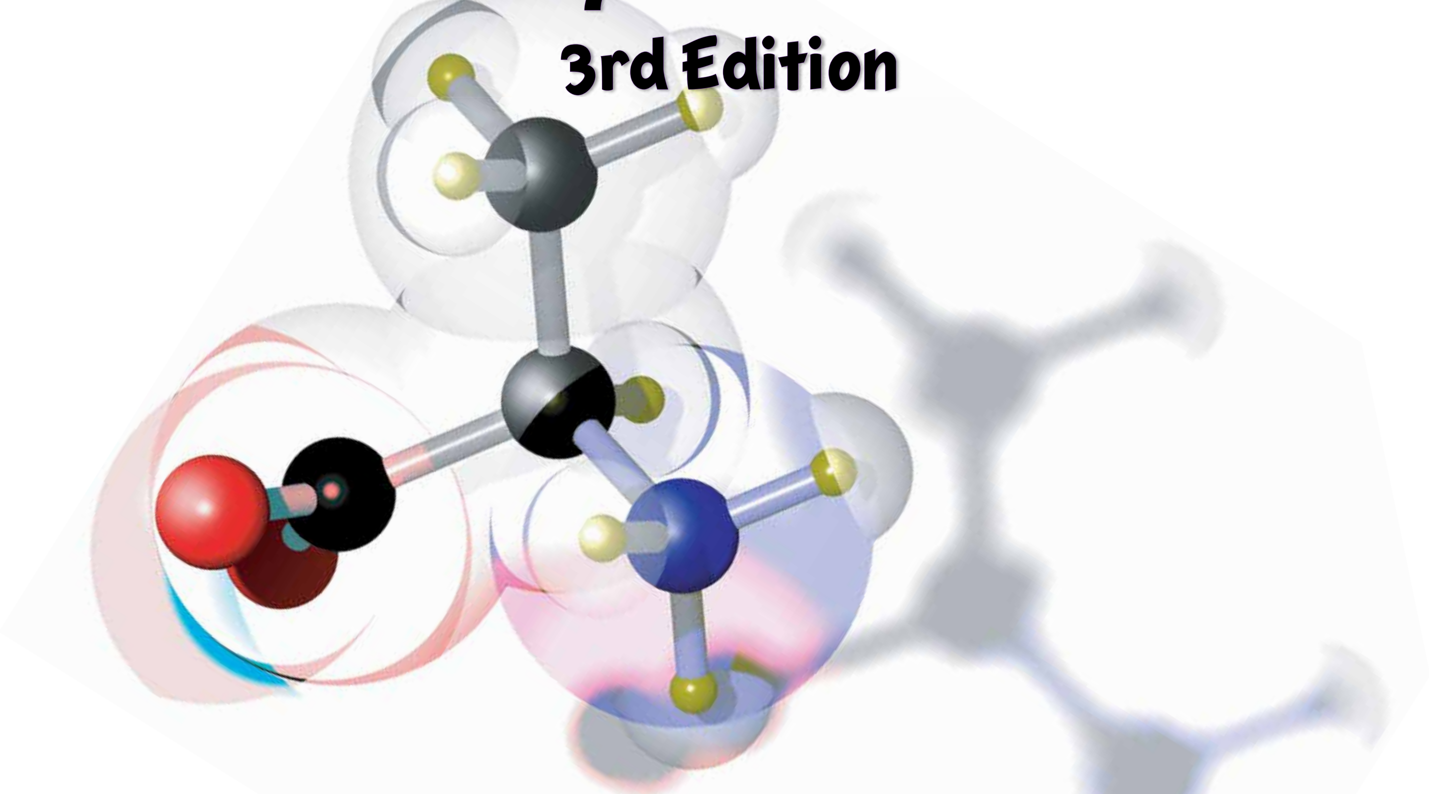
Focus On

Grades 5-8

Middle School Chemistry

Study Notebook

3rd Edition



Rebecca W. Keller, PhD

Real Science 4 Kids

Illustrations: K. Keller

Focus On Middle School Chemistry Study Notebook

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Welcome to your Study Notebook

This notebook is your place to record anything you want as you learn about atoms and molecules, acids and bases, pure substances and mixtures, bonding and chemical reactions, polymers and DNA, and all the other amazing facts and concepts we call chemistry.

There are questions and suggestions. Some are serious and some are whimsical. If you don't like them, cross them out and create your own.

Just explore what you think about all the topics you are learning and try not to get too worried about writing down the "right" answers. This is an opportunity for you to explore what YOU like.

There are places in this notebook that are unscripted and have little instruction. There are also questions that just dangle on the edges of the page. That's OK. Just record, draw, or paste images that you think apply. Add extra pages as you like. Answer the questions and suggestions in a way that makes the most sense to you. Most of real science is unscripted and making discoveries has no set of instructions. Just play with it. You'll be fine and you might find out something unexpected and amazing.

This notebook is not meant to be graded. So parents and teachers, just let it go. Don't grade this notebook or make your student "turn it in." If your student wants to share all they are learning, great! If not, let that be OK too.

day month year

CHAPTER 1

How would you describe what an atom is?

Illustrate what you are thinking

The philospher Anaximander thought that the '**essence**' or true nature of things could be found in what he called the 'boundless'.

What do you think of this concept? Is there anything in nature you can describe as **boundless**?

write or draw your thoughts about boundlessness

Look up Antoine Lavoisier's *Elements of Chemistry* and John Dalton's *A New System of Chemical Philosophy.* Write down five stated facts you can find in each volume.

Elements of Chemistry	A New System
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.

Compare these facts to anything you have learned so far about science. Is there anything in these books you do not think is true? (there my not be, just think about it)

We know that atoms are the building blocks for matter. How do you consider matter? Is matter everything?

or does it not matter?

Everything is made of something.
Pick some of your favorite things and draw what they are made of.

make drawings of them!

day month year

CHAPTER VII

When is something neutral? Is this a common state?

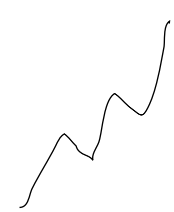
Assay:

Titration:

Exchange Reaction:

Decomposition Reaction:

Make a plot of something.



Name ____________________________ **Date** ___________________

Focus On Middle School Chemistry 3rd Edition - Midterm 1
Chapters 1-6, 18 questions, 10 points each

1. In the 17th and 18th centuries, some important advancements in science were... (Check the one statement that is incorrect.) (10 points)
   - ○ The adoption of doing quality scientific experiments to prove or disprove ideas.
   - ○ Joseph Priestley's discovery of carbon dioxide gas.
   - ○ Antoine Lavoisier showing that water is made of oxygen and nitrogen.
   - ○ John Dalton proposing that all elements are made of atoms and that each atom has its own atomic weight.
   - ○ Boyle's experiments showing that different kinds of atoms could combine to form molecules.

2. The early Greek philosophers... (Check all that apply.) (10 points)
   - ☐ Had many different theories about matter.
   - ☐ All believed that everything is made of earth, air, fire, and water.
   - ☐ Didn't know much.
   - ☐ Argued about their different ideas.
   - ☐ All came to agreement that the atom is the smallest unit of matter.

3. The alchemists... (10 points)
   - ○ Did experiments that turned lead into gold.
   - ○ Wore pointy hats and did magic tricks that changed atoms from one type to another.
   - ○ Were true chemists and used a scientific method to do experiments.
   - ○ Learned a lot about the properties of matter.

Focus On Middle School Chemistry 3rd Edition - Midterm 2
Chapters 7-12, 18 questions, 10 points each

1. Which of the following describe an acid-base reaction? (Check all that apply.) (10 points)
   - ☐ A titration is caused by an acid-base reaction.
   - ☐ It is a special kind of exchange reaction.
   - ☐ The reaction between baking soda and vinegar is an acid-base reaction.
   - ☐ It is called a neutralization reaction because it doesn't care one way or the other.
   - ☐ When an equal concentration of a strong acid reacts with an equal concentration of a strong base, the resulting solution is neutral.
   - ☐ Taking ping-pong balls out of a box reaults in a reaction.

2. To find out the concentration of an unknown acid or base, you can... (10 points)
   - ○ Use ping-pong balls.
   - ○ Perform a titration.
   - ○ Weigh the molecules.
   - ○ Use the periodic table.
   - ○ Use litmus paper.

3. In chemistry, a mole is... (10 points)
   - ○ The name for the weight of one molecule.
   - ○ An atomic mass unit (amu).
   - ○ the name for a certain number of atoms, molecules, or ions.
   - ○ A common skin growth.
   - ○ A little gray animal.

Focus On Middle School Chemistry 3rd Edition - Final Quiz
Chapters 1-12, 24 questions, 10 points each

1. An early Greek philosopher developed the theory that the smallest piece of matter is the atom, but it was 2000 years before this idea was accepted by science. (10 points)
   - ○ True
   - ○ False

2. The alchemists were not considered to be true scientists because... (10 points)
   - ○ They made the king angry by asking for money.
   - ○ They did not use the proper equipment.
   - ○ They did not approach their work with a scientific method.
   - ○ They did not find out how to turn lead into gold.
   - ○ They were not good at doing magic.

13. By doing a titration we can... (Check all that apply.) (10 points)
   - ☐ Find out how many ping-pong balls are in a box.
   - ☐ Get data to plot a graph showing a change in pH.
   - ☐ Find out the concentration of an unknown solution of acid or base.
   - ☐ Watch the pH of a solution change.

14. An acid and a base will ______________ each other in an acid-base reaction. (10 points)
   - ○ weaken
   - ○ authorize
   - ○ strengthen
   - ○ compromise
   - ○ neutralize

Answer Sheet

Focus On Middle School Chemistry 3rd Edition - Midterm 1
Chapters 1-6, 18 questions, 10 points each

1. Antoine Lavoisier showing that water is made of oxygen and nitrogen.
2. Had many different theories about matter., Argued about their different ideas.
3. Learned a lot about the properties of matter.

Focus On Middle School Chemistry 3rd Edition - Midterm 2
Chapters 7-12, 18 questions, 10 points each

1. It is a special kind of exchange reaction., The reaction between baking soda and vinegar is an acid-base reaction., When an equal concentration of a strong acid reacts with an equal concentration of a strong base, the resulting solution is neutral.
2. Perform a titration.
3. the name for a certain number of atoms, molecules, or ions.

Focus On Middle School Chemistry 3rd Edition - Final Quiz
Chapters 1-12, 24 questions, 10 points each

1. True
2. They did not approach their work with a scientific method.

13. Get data to plot a graph showing a change in pH., Find out the concentration of an unknown solution of acid or base., Watch the pH of a solution change.
14. neutralize

Grades 5-8

Focus On Middle School Chemistry

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Rebecca W. Keller, PhD

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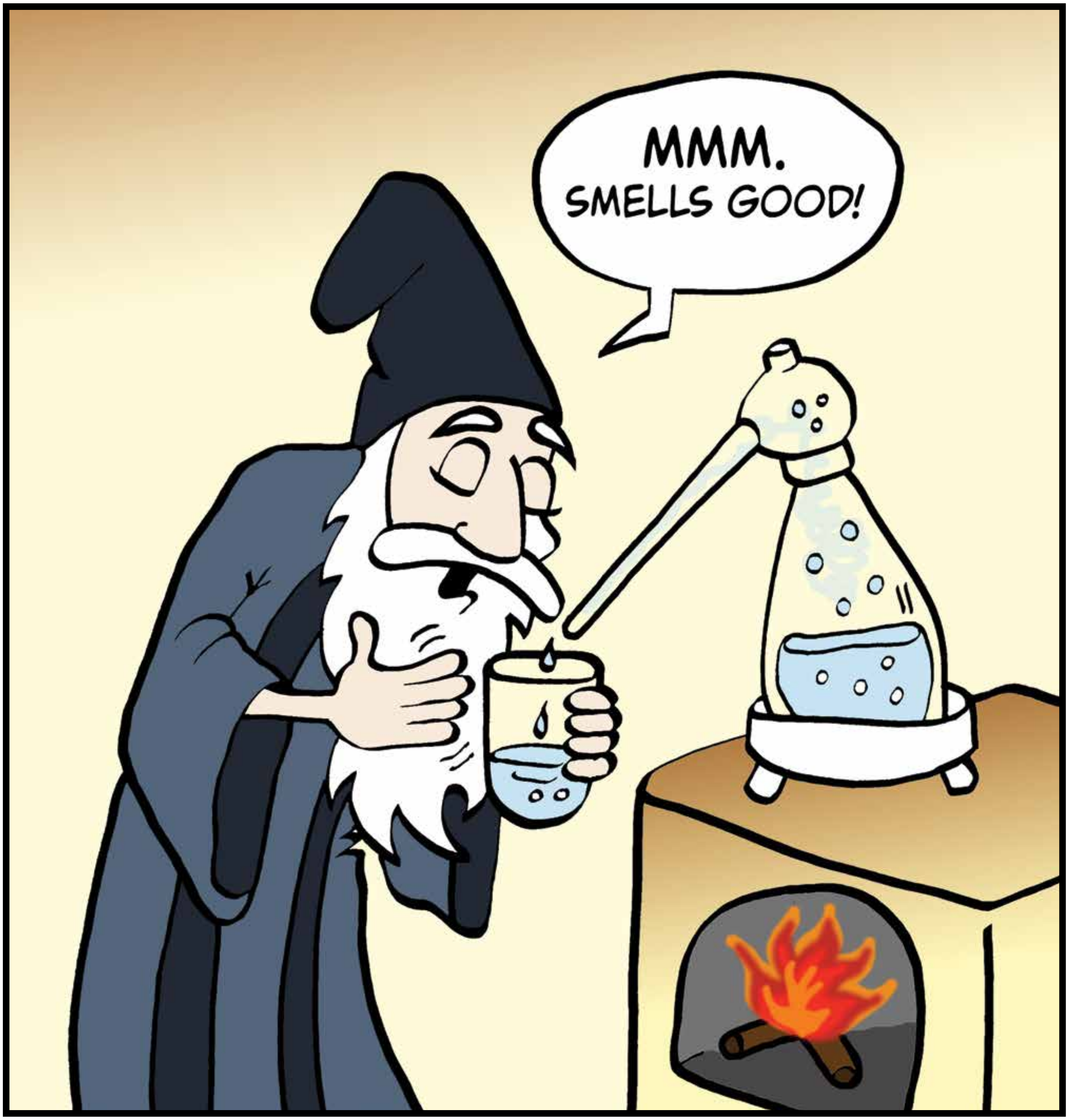
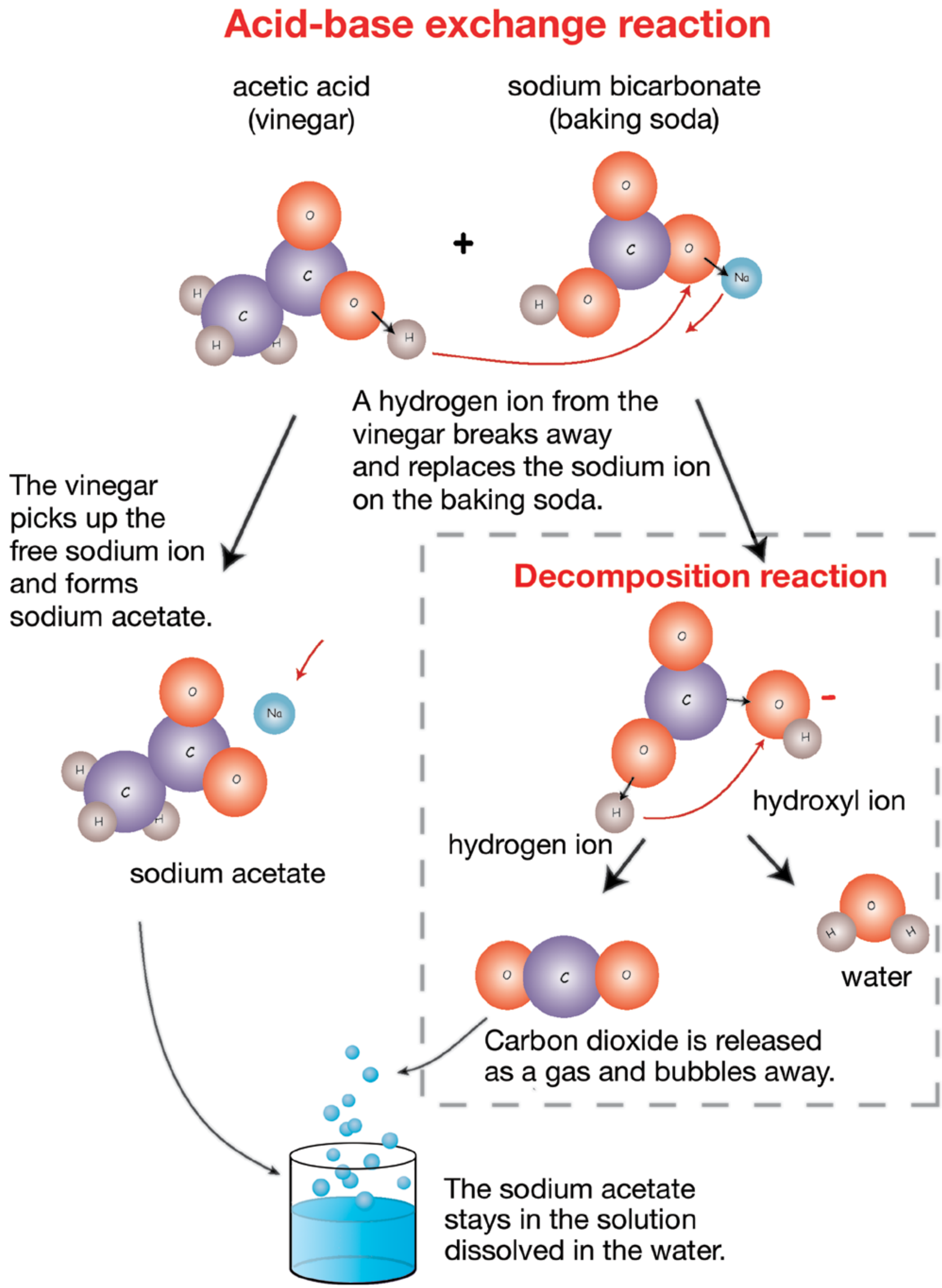
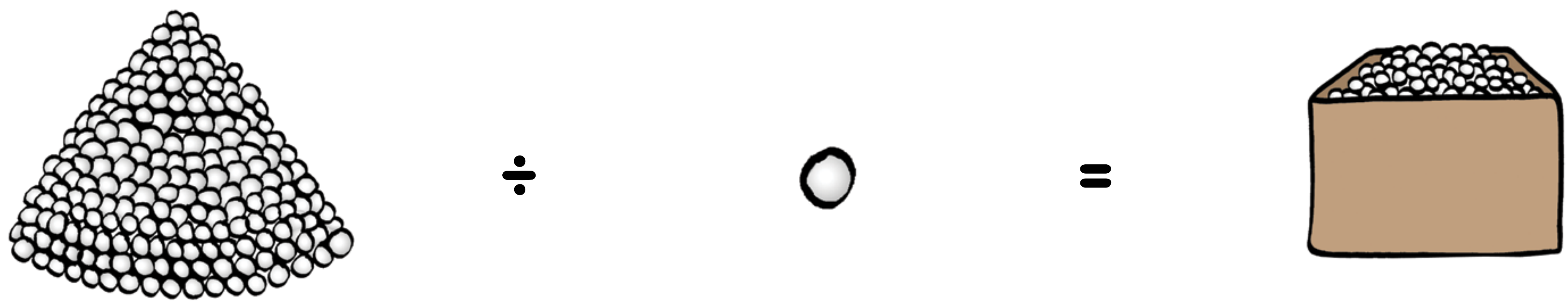

MMM.
SMELLS GOOD!


HA!
HA! HA!



Acid-base exchange reaction
acetic acid
(vinegar)
sodium bicarbonate
(baking soda)
+
A hydrogen ion from the vinegar breaks away and replaces the sodium ion on the baking soda.
The vinegar picks up the free sodium ion and forms sodium acetate.
sodium acetate
Decomposition reaction
hydroxyl ion
hydrogen ion
water
Carbon dioxide is released as a gas and bubbles away.
The sodium acetate stays in the solution dissolved in the water.



Total weight of ping-pong balls (800 grams) ÷ Weight of one ping-pong ball (8 grams) = Number of ping-pong balls (100)

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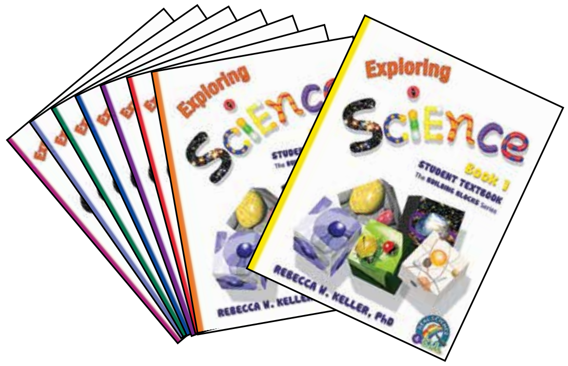

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