Real Science-4-Kids

CHEMISTRY

Level I

Teacher's Manual

Rebecca W. Keller, Ph.D.

Cover design: David Keller
Opening page: David Keller, Rebecca W. Keller, Ph.D.
Illustrations: Rebecca W. Keller, Ph.D.

Real Science-4-Kids: Chemistry Level I Teacher's Manual

ISBN 10: 0-9749149-8-3
ISBN 13: 9780974914985

Published by Gravitas Publications, Inc.
4116 Jackie Road SE, Suite 101
Rio Rancho, NM 87124
www.gravitaspublications.com

Printed in United States

A Note from the Author

This curriculum is designed to give students both solid science information and hands-on experimentation. Level I is geared toward fourth through sixth grades, but much of the information in the text is very different from what is taught at this grade level in other textbooks. I feel that students beginning with the fourth grade can grasp most of the concepts presented here. This is a *real* science text, so scientific terms are used throughout. It is not important at this time for the students to master the terminology, but it *is* important that they be exposed to the real terms used to describe science.

Each chapter has two parts: a reading part in the textbook and an experimental part in the laboratory workbook. In the teacher's manual, an estimate is given for the time needed to complete each chapter. It is not important that both the reading portion and the experimental portion be conducted in a single sitting. It may be better to split these into two separate days, depending on the interest level of the child and the energy level of the teacher. Also, questions not addressed in the teacher's manual may arise, and extra time may be required to investigate these questions before proceeding with the experimental section.

Each experiment is a *real* science experiment and not just a demonstration. These are designed to engage the students in an actual scientific investigation. The experiments are simple, but they are written the way real scientists actually perform experiments in the laboratory. With this foundation, it is my hope that the students will eventually begin to think of their own experiments and test their own ideas scientifically.

Enjoy!

Rebecca W. Keller, Ph.D.

How to use this manual

The Chemistry Level I Teacher's Manual provides directions for the laboratory experiments and answers to the questions asked in each experiment. It also contains additional information for both the textbook and the experiments. The additional information for each chapter is provided as supplementary material in case questions arise while reading the textbook or performing the experiments. It is not necessary for the students to learn this additional material as most of it is beyond the scope of this level. However, the teacher may find it useful for answering questions.

The laboratory section (Experiment) is found at the end of each chapter in this manual. All of the experiments have been tested, but it is not unusual for an experiment to fail. Usually, repeating an experiment helps both student and teacher see where an error may have been made. However, not all repeated experiments work either. Don't worry if an experiment fails. Encourage the student to troubleshoot and investigate possible errors.

Getting started

The easiest way to follow this curriculum is to have all of the materials needed for each lesson ready before you begin. A small shelf or cupboard or even a plastic bin can be dedicated to holding most of the necessary chemicals and equipment. Those items that need to be fresh are indicated at the beginning of each lesson. The following *Materials at a Glance* chart lists all the experiments and the materials needed for each. A materials list is also provided at the beginning of each experiment.

Materials at a Glance

Experiment 1	Experiment 2	Experiment 3	Experiment 4	Experiment 5
pen paper food labels dictionary encyclopedia periodic table of elements (from Chemistry Level I textbook)	small, colored marshmallows large marshmallows toothpicks	baking soda lemon juice balsamic vinegar salt (1-2 tbsp. dissolved in 1/2 cup of water) egg whites milk several small jars measuring cups measuring spoons eye dropper	one head red cabbage distilled water ammonia vinegar soda pop milk mineral water large saucepan small jars coffee filters (white) eye dropper measuring cup measuring spoons marking pen scissors ruler	red cabbage indicator (from Experiment 4) household ammonia vinegar large glass jar measuring spoons measuring cup

Experiment 6	Experiment 7	Experiment 8	Experiment 9	Experiment 10
water ammonia vegetable oil rubbing alcohol melted butter vinegar small jars (7 or more) food coloring dish soap eye dropper measuring spoons measuring cup marking pen	ballpoint ink pens (various colors) black ballpoint ink pen rubbing alcohol coffee filters (white) several small jars cardboard shoe box tape measuring cup scissors ruler	tincture of iodine (from Walgreen's or other pharmacy) raw food items: pasta, bread, celery, potato, banana, apple, etc. liquid laundry starch absorbent white paper eye dropper cookie sheet marking pen	liquid laundry starch (or Borax) Elmer's white glue Elmer's blue glue (or another glue different from white glue) water 2 small jars marking pen Popsicle sticks for stirring measuring spoons	tincture of iodine (from Walgreen's or other pharmacy) bread timer wax paper marking pen cup

Laboratory safety

Most of these experiments use household items. However, some items, such as iodine, are extremely poisonous. Extra care should be taken while working with all chemicals in this series of experiments. The following are some general laboratory precautions that should be applied to the home laboratory:

- Never put things in your mouth unless the experiment tells you to. This means that food items should not be eaten unless tasting or eating is part of the experiment.
- Use safety glasses while using glass objects or strong chemicals such as bleach.
- Wash hands after handling all chemicals.
- Use adult supervision while working with iodine or glassware and while conducting any step requiring a stove.

Contents

Chapter 1: Matter

Time Required

Text reading	30 minutes
Experimental	1 hour

Materials

pen and paper
food labels
dictionary
encyclopedia
periodic table of elements (from student textbook)

Overall Objectives

This chapter will introduce the concept that all things, living and nonliving, are made of the same fundamental components called atoms. It is important to help the students understand that although the world is full of a large number of both living and nonliving things, there is only a limited number of atoms, or elements, that make up all things. The variety observed in all things is a result of the vast number of ways that atoms can be combined with one another. For example, sodium (Na) is combined with chlorine (Cl) to make "sodium chloride" (NaCl) which is table salt. However, if you add an oxygen atom (O) to make "sodium hypochlorite," NaOCl, you get bleach.

1.1 Introduction

Matter is a general term for the substance of which all things are composed.

Chemistry is that area of science mainly concerned with the ways in which atoms combine to form chemical bonds.

There are several different subdisciplines within chemistry:

- *Physical chemistry* is concerned with the fundamental physics of atoms.
- *Biochemistry* is concerned with matter that makes up living things.
- *Organic chemistry* is concerned with the chemistry of carbon (C) containing compounds.
- *Analytical chemistry* deals with analyzing the composition of matter.
- *Inorganic chemistry* is concerned mostly with non-carbon compounds.

1.2 Atoms

The students will be introduced to the following terms:

- Atoms
- Protons
- Neutrons
- Electrons

Atoms, protons, neutrons and electrons are more specific terms for matter.

Atoms are very small and cannot be seen by the naked eye. If an atom were the size of a tennis ball, the average man (6 ft. tall) would stand one million kilometers high — almost the distance from here to the sun.

Protons and neutrons are roughly equal in size, and both have an atomic mass of 1 amu (atomic mass unit). A proton carries a positive charge, and a neutron carries no charge; it is neutral. By comparison, the electron is 1/1836 of the mass of a proton. The electron carries a negative charge that is equal in magnitude to the charge on a proton. For neutral atoms, the number of

electrons equals the number of protons. The number of neutrons does not always equal the number of protons or electrons in neutral atoms.

The nucleus contains the protons and neutrons and is much smaller than the full atom. Most of the volume of an atom is occupied by the electrons.

The space occupied by the electrons surrounds the proton-neutron core and is called an orbital or electron cloud. Orbitals can have a variety of shapes, which the students will learn later on. The different shapes of electron clouds are very important for understanding how atoms combine with each other. (See Chemistry Level II.)

1.3 Periodic Table

The periodic table of elements is a large chart that organizes and categorizes all of the elements according to their chemical properties.

The periodic table illustrates the general law of periodicity among all of the elements. This means that certain chemical properties of the atoms repeat. For example, fluorine (F) undergoes chemical reactions similar to those of chlorine (Cl), bromine (Br), iodine (I), and astatine (At). All of these similar elements are arranged in a single column of the periodic table. Grouping the elements according to their chemical properties gives rise to the "periods" which are the horizontal rows.

There are three short periods of 2, 8, and 8 elements:

- hydrogen -> helium [period of 2 elements]
- lithium -> neon [period of 8 elements]
- sodium -> argon [period of 8 elements]

and then three longer periods of 18, 18, and 32:

- potassium -> krypton [period of 18 elements]
- rubidium ->xenon [period of 18 elements]
- cesium ->radon [period of 32 elements]

The final period is predicted to contain 32 elements, but notice that the last elements are as yet undiscovered.

The last naturally occurring element is uranium with 92 protons. The elements after uranium are artificially made.

The symbols of the elements are not always the same as the first letter or two of the English name since some elements were named in other languages. Some examples are given in the student textbook.

Page 5 of the student textbook gives a brief explanation of some of the details in the periodic table.

The number in the upper-left-hand corner of each element square is the atomic number. This number tells how many protons the atom contains. The atomic number is not always in the upper-left-hand corner of the block

representing the element — it can be in the middle or on the right.

The number below the name is the atomic weight. The atomic weight is the sum of the weight of the protons, neutrons, and electrons. Because the electrons have essentially no mass, the atomic weight can be considered to be the sum of just the weight of the protons and neutrons. Because protons and neutrons are essentially "1 atomic mass unit" each, the number of neutrons can be determined by subtracting the atomic number from the atomic weight.

EXAMPLE:
Hydrogen has an atomic number of 1. This means that hydrogen has one proton. Hydrogen has an atomic weight close to one, which means that all of the weight is due to the single proton. There are no neutrons.

Another example is uranium:

- number of protons: 92
- atomic weight: 238
- number of neutrons: 238 minus 92 = 146

NOTE:
Although the atomic weight is actually 238.0289, it is rounded to 238 to calculate the number of neutrons.

Vertically, the elements are organized according to similar chemical properties.

The elements on the far right of the periodic table are the noble gases. In general, the noble gases do not react with other elements. It is possible to get some of the noble gases to react, but it is very difficult. The noble gases are always found in nature as single atoms and not in pairs like other gases such as oxygen and nitrogen.

The elements on the far left are called the alkali metals. These elements are very reactive. Lithium (Li), sodium (Na), and potassium (K) react very violently with water. They also form salts with the halogens, which form the column to the left of the noble gases. Some common salts include sodium chloride (NaCl), lithium chloride (LiCl), and potassium chloride (KCl). Sodium chloride (NaCl) is common table salt. Potassium chloride (KCl) is a table salt alternative that is used by many people with high blood pressure.

There are other "trends" or properties that are illustrated in the periodic table, such as atomic size and electronegativity, and these will be introduced later.

The most important points to emphasize about the periodic table are the following:

- All of the elements that make up all things, living and nonliving, are in the periodic table.
- The periodic table illustrates an underlying order or "periodicity" among all of the elements.
- Mendeleev discovered the overall order of elements through scientific investigation and assembled the first periodic table.

1.4 Summary

Discuss with the students the main points of this chapter.

- Point out that everything we can touch is made of atoms. Have the students name several different items and discuss how these items are all made of atoms.
- Review that atoms are made of smaller particles called protons, neutrons, and electrons. Protons and neutrons form the atomic core, or nucleus, and electrons are found in the electron cloud surrounding the nucleus.
- Review that the number of protons equals the number of electrons in an atom. This is true for neutral atoms. It is possible to remove an electron from an atom or add an electron to an atom. The atom is then called an ion and has a positive or negative charge. (See Chapter 6 and the Chemistry Level II student text.)
- All of the elements known are found in the periodic table of elements. New elements can be made artificially, but all naturally occurring elements are already known.
- Review that in the period table all of the elements are in groups that are similar. For example, the noble gases behave similarly and are in the same column.

The goals of this experiment are to help the students begin to investigate the things in their world and to have them start to examine what those things are made of.

There are many "right" answers for this experiment, and the elemental composition will not be available for all of the items from basic resources such as the dictionary or encyclopedia. Some examples of answers are the following:

Things made of metals:

- *soda cans and aluminum foil - aluminum*
- *silverware (steel) - iron, nickel, silver*
- *coins - copper, nickel*
- *jewelry - gold, silver*

Things we eat:

- *salt - sodium and chlorine*
- *sugar - carbon, oxygen, hydrogen*
- *water - hydrogen and oxygen*
- *bread (carbohydrates) - carbon, oxygen, hydrogen, and other proteins and things*

Also, students can select food items with labels, such as cake mixes, cereal, noodles, and vitamins (with vitamins the label is very detailed, and the students can also find out how much of something is in the vitamin).

The students DO NOT need to find out every component for each item. To say that cake mix contains salt, flour, and sugar is enough. Let the students go as far as they want with a particular item. Also, it is not necessary to look up components for each item given. Pick a few and go from there.

Experiment 1: What is it made of?

Date: _____

Objective

To become familiar with the periodic table of elements and investigate the composition of some common items

Materials

pen

paper

food labels

dictionary

encyclopedia

periodic table of elements

Experiment

Record your answers on the next page.

❶ Using the periodic table of elements, answer the following questions:

A. How many protons does aluminum have? How many electrons?

B. What is the symbol for carbon?

C. List all of the elements that have chemical properties similar to helium.

D. What is the atomic weight of nitrogen? How many neutrons does nitrogen have?

❷ Think of several different items, and write them in the column labeled "Item." These can be any item, like "tires" or "cereal." Try to be specific. For example, instead of writing just "cereal," write "corn cereal" or "sweet, colored cereal."

❸ In an encyclopedia or on the food label, look up the composition of the items you have selected, and write this information in the column labeled "Composition." Try to be as specific as possible when identifying the composition. For example, if your cereal contains vitamin C, write "sodium ascorbate" if that name is also listed. Try to identify any elements in the compounds you have listed. For example, vitamin C contains the element "sodium."

❹ Write the source next to the composition. "Source" means where you got your information; for example, "food label" or "encyclopedia."

Answers to Questions

(Answers may vary.)

❶ A. *Aluminum has 13 protons. Aluminum also has 13 electrons.*

B. *The symbol for carbon is "C."*

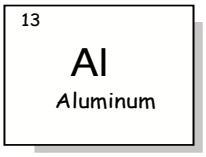
C. *The elements that have the same chemical properties as helium are neon, argon, krypton, xenon, and radon.*

D. *The atomic weight for nitrogen is 14.0067. Nitrogen has 7 neutrons.*

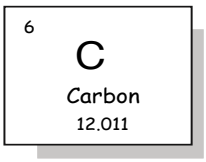
(Answers may vary.)

	❷ Item	❸ Composition	❹ Source
1.	*car tires*	*rubber (carbon and hydrogen)*	*Webster's Dictionary, page 1582*
2.	*graham crackers*	*sodium bicarbonate (sodium)*	*food label*
3.	*graham crackers*	*salt (sodium, chlorine)*	*food label, dictionary-page 1600*
4.			
5.			
6.			
7.			
8.			

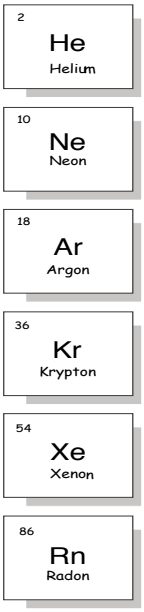
Aluminum (Al) has 13 protons. This means aluminum has 13 electrons as well.

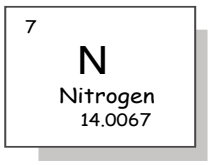


The symbol for carbon is "C."



The elements that have the same chemical properties as helium are in the same column in the periodic table.





The atomic weight for nitrogen is 14.0067. To calculate the number of neutrons, subtract the number of protons (7) from the atomic weight. 14 - 7 = 7. Nitrogen has 7 neutrons. It has the same number of neutrons as it has protons.

Help the students write accurate statements about the data they have collected. Some examples are given.

Next, help the students think specifically about what their data show. This is an important critical thinking step that will help them evaluate future experiments.

Try to help them write concluding statements that are valid. Encourage them to avoid stating opinions or any conclusions that cannot be drawn strictly from their data.

For example, it may be true that all cereals contain "salt." However, this particular investigation cannot confirm or deny that conclusion. The most that can be stated from this investigation is "Brand X contains salt and Brand Y contains salt," but any further statement is conjecture.

Help them formulate their conclusions using the words *some, all, many*, and *none*. Point out that the statement, "All cereals contain salt," is not valid, but based on this investigation, it is valid to say, "Some cereals contain salt."

Again, there are numerous "right" answers. One student may list "sugar" as a component in soup, and another may list "salt," and both could be "right." The true test is whether the statements about the data are valid or not valid.

Also, try to show them where broad statements can be made validly. For example, "All U.S. pennies contain copper" is probably a valid statement even though we haven't checked every U.S. penny.

This may seem fairly subtle, but the main point is to help them understand the kinds of valid conclusions science can offer based on scientific investigation.

Results

(Answers may vary.)

Briefly describe what you discovered about the composition of the various items.

For example:

Kellogg's Sugar Smacks™ cereal contains vitamin C, which is called sodium ascorbate.

Table salt is made of sodium and chlorine.

Iodized table salt contains sodium, chlorine, and iodine.

Chocolate cake mix contains sugar.

Sugar has oxygen, hydrogen, and carbon in it.

Conclusions

(Answers may vary.)

State your conclusions based on the information you collected.

For example:

Many cereals contain sodium as part of salt and vitamin C.

Some peanut butter contains sugar.

Rubber contains carbon and hydrogen.

Review

Define the following terms:
(Answers may vary.)

chemistry *a branch of science concerned with the properties of matter*

matter *a general term for what makes up all things*

atoms (atomos) *the fundamental building blocks of matter. Atomos is a Greek word that means uncuttable*

proton *a small particle found inside atoms*

neutron *another small particle found inside atoms*

electron *a particle found in an atom that is very much smaller than both protons and neutrons*

nucleus *the central portion of an atom that consists of only the protons and neutrons*

electron cloud *the space occupied by the electrons surrounding the nucleus*

element *another name for any of the distinct atoms in the periodic table*

atomic weight *the total weight of an atom; the weight of the protons and neutrons combined*