LIFEPAC®

SCIENCE

STUDENT BOOK

8th Grade | Unit 1

Alpha Omega PUBLICATIONS

SCIENCE 801
Science and Society

LIFEPAC Test is located in the center of the booklet. Please remove before starting the unit.

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Alpha Omega PUBLICATIONS

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Science and Society

Introduction

In our world today we are aware of new discoveries and inventions in every area of life. A cure for a disease, a pollution-control device for cars, a new type of toy, all point to the fields of science and technology. We owe most of the comforts, conveniences, and pastimes of modern living to these fields.

In this LIFEPAC® you will learn some of the backgrounds of science and technology and the ways in which scientists and technicians proceed with their work. You will study the history of science and technology, the scientific method, systems of measurement, and advances in science and technology. We will also discuss a few of the great variety of products of science and technology.

You will enjoy this LIFEPAC and the activities it contains. It deals with ideas and experiences that are familiar to you. Science and technology are noble professions when God is given the glory.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC. When you have finished this LIFEPAC, you should be able to:

1. Define *science* and *technology*.
2. State the major points in the history of science and technology.
3. List the steps of the scientific method.
4. Demonstrate the use of basic principles of scientific measurement.
5. Name at least two goals of science and technology.
6. Explain why science and technology are limited.
7. Discuss at least one problem being created by technology and one problem being solved by technology

Survey the LIFEPAC. Ask yourself some questions about this study and write your questions here.

1. SCIENCE TODAY

Science today is based on the work of great people in the past. Those individuals did not stand by and allow others to accomplish their tasks, they had ideas, and they put those ideas into action. In this section we will learn what science is and what we owe to the scientists of yesterday. Then we shall consider how scientists do their work today.

SECTION OBJECTIVES

Review these objectives. When you have completed this section, you should be able to:

1. Define *science* and *technology*.
2. State the major points in the history of science and technology.
3. List the steps of the scientific method.
4. Demonstrate the use of basic principles of scientific measurement.

VOCABULARY

Study these words to enhance learning success in this section.

alchemy (al´ ku mē). The attempt to change base metals into gold by a mixture of science and magic.

atom (at´ um). A building block of all matter.

base metals (bās met´ ulz). Metals less valuable than gold.

electron (i lek´ tron). A negatively charged atomic particle.

evolution (ev u lü´ shun). The theory that all organisms develop from simpler organisms.

experimentation (ek sper´ u men tā´ shun). Doing repeated tests to prove a scientific fact.

exponent (ek spō´ nunt). The power to which a number is raised.

gram (gram). The standard metric unit of mass.

hypothesis (hī poth´ u sis). A probable answer to a scientific problem.

law (lô). A proven scientific fact.

liter (lē´ tur). The standard metric unit of volume.

meter (mē´ tur). The standard metric unit of length.

metric system (met´ rik sis´ tum). A system of measurement based on the number ten.

neutron (nü tron). A neutral atomic particle.

organism (ôr´ gu niz um). An individual animal or plant.

philosopher (fu los´ u fur). A person who is guided in his life by the principle that humans are rational and social beings.

poliomyelitis (po´ lē ō mī´ u lī´ tis). A crippling disease.

proton (prō´ ton). A positive atomic particle.

Renaissance (ren´ u säns). The rebirth of true learning.

scholastics (sku las tiks). Medieval individuals who catalogued the ideas of ancient philosophers.

science (sī´ uns). Orderly knowledge demonstrated by repeatable tests.

scientific method (sī´ un tif ik meth´ ud). The nine steps a scientist uses in his work.

scientific notation (sī´ un tif ik nō tā´ shun). A system of writing numbers less than 0.1 and greater than 100 as a multiple of a power of 10.

second (sek´ und). The standard unit of time.

significant figures (sig nif´ u kunt fig´ urz). Those digits in a number that have true value.

species (spē´ shēz). A group of animals or plants that have characteristics in common and are able to interbreed.

summa (süm´ u). An encyclopedia-like document written by a scholastic.

theory (thē´ ur ē). A probable solution to a scientific problem.

Note: *All vocabulary words in this LIFEPAC appear in* **boldface** *print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.*

Pronunciation Key: h**a**t, **ā**ge, c**ã**re, f**ä**r; l**e**t, **ē**qual, t**ė**rm; **i**t, **ī**ce; h**o**t, **ō**pen, **ô**rder; **oi**l; **ou**t; c**u**p, p**u̇**t, r**ü**le; **ch**ild; lo**ng**; **th**in; /*ŦH*/ for **th**en; /*zh*/ for mea**s**ure; /*u*/ represents /*a*/ in **a**bout, /*e*/ in tak**e**n, /*i*/ in penc**i**l, /*o*/ in lem**o**n, and /*u*/ in circ**u**s.

A DEFINITION OF SCIENCE

Let us develop a definition for the word **science**.

Knowledge. The word *science* comes from a Greek word meaning *knowledge*. It is not enough, however, to state that science is knowledge, for many other areas come under this heading. If we add *orderly* to the word *knowledge*, we have narrowed our definition of science somewhat. Science is orderly knowledge. The statement "Ducks can swim, bears sleep in winter, and skunks smell," is correct; these facts are knowledge. The statement "Different animals have certain characteristics that distinguish them from other animals: for example, ducks can swim, bears sleep in winter, and skunks have an unpleasant odor," is a more orderly way of presenting the same facts. It is more scientific.

Again, science is more than orderly knowledge. Orderly knowledge can be found in fields other than science. The one area in which science differs from other fields of knowledge is **experimentation**. *Experimentation* means *demonstrating a fact by testing to see if the same result occurs repeatedly.* For example, everyone knows ducks can swim. Some people even know that swimming is a characteristic that makes ducks different from most other birds. A scientist, however, would attempt to prove this fact by placing several ducks in a pool of water. He would then watch to see if they could swim. He would be doing a test or **experiment** to prove that ducks can indeed swim. He would also be able to repeat the experiment with other ducks to show the same fact. Thus, science is *orderly knowledge demonstrated by repeatable experiments*.

Doing an experiment to prove something as well-known as the fact that ducks can swim may seem ridiculous but it is not. Without people who were willing to look ridiculous by doing experiments to prove ideas true or false, we might still believe some very false ideas. We will learn about some of these people in the next section.

Write these statements in the proper order.

a. Science is orderly knowledge.
b. Science is orderly knowledge proved by experiments.
c. Science is knowledge.

1.1 ____

1.2 ____

1.3 ____

Complete these statements.

1.4 A scientific test is a(n) ______________________________ .

1.5 Science comes from a Greek word meaning ____________________ .

1.6 Scientists perform experiments to prove ideas a. ________________ or

b. ____________________ .

Define this term.

1.7 Science ____

____

Describe how you could prove this statement.

1.8 Cats eat fish. ____

____

____

____

A BRIEF HISTORY OF SCIENCE

When we think of science, usually we think of it as it is today—clean white labs, computers, serious men and women watching video monitors, huge telescopes pointing to the stars. Science, however, is not a new subject. People have been seeking to understand God's creation ever since the Creation.

Ancient Science. Though science began soon after mankind was created, science as an orderly system of thought did not begin until a Greek named Aristotle began to write down his ideas. Aristotle was a **philosopher** who wrote his ideas in an orderly manner. He studied nature and, among other things, tried to figure out a systematic classification for plants and animals. Though his ideas were orderly and written down, Aristotle is not considered a true scientist. He had ideas, but he never investigated to see if they were true. He never performed experiments. Because of this lack of experimentation, many of his ideas were faulty. However, Aristotle's writings still are of value because they have inspired many later scientists.

Another important Greek philosopher was Democritus. He was one of the first men to believe that all things consist of tiny particles of matter. He thought that, if you cut a piece of matter in half and then in half again and again, you would ultimately arrive at a piece so small that it could not be halved. He termed this smallest piece of matter an **atom** which means *not able to be cut*. Atoms are quite small, but we now know that they are made of particles even smaller. Although Democritus' concept was not entirely correct, all our atomic science is indebted to his idea.

Write the letter of the correct answer in the blank.

1.9 Science is a(n) ________________ subject.
a. new b. old c. unimportant

1.10 Aristotle was a ________________ .
a. Greek philosopher b. Roman politician
c. French scholastic

1.11 Aristotle tried to put facts in ________________ .
a. an encyclopedia b. a monastery c. an orderly pattern

1.12 Democritus termed the smallest particle ________________ .
a. matter b. an atom c. a molecule

Answer true or false.

1.13 __________ Aristotle did many experiments.

1.14 __________ Democritus was a Greek philosopher.

1.15 __________ Aristotle was the first to have the idea of the atom.

Answer this question.

1.16 What effect did the lack of experimentation have on the work of Aristotle and Democritus?

____

____

Medieval science. In the Middle Ages, which followed the barbarian invasions of the Roman Empire, science continued to exist, but not as we know it today. The most common form of science in the Middle Ages was **alchemy**. Alchemists were people who were interested in gaining great wealth. They thought it was possible to turn less valuable metals (**base metals)**—such as tin, copper, and lead—into gold. Of course, we know this process is not possible; but they did follow a somewhat scientific method. They did some reasonable things such as heating metals and pouring acids on them. Other procedures they used, however, were less than scientific. They relied upon magic to do what science seemed unable to accomplish. Of course, the alchemists never succeeded; but they did keep alive the idea of scientific investigation.

Other factors in science at this period in history were the Arabs and the **scholastics**. The Arab Moors tried to invade Europe though Spain. They wished to spread the Muslim religion throughout the world. The Moors brought with them advanced ideas in medicine and other scientific fields. Had they succeeded in conquering Europe, Christianity would have suffered; but Western science might have advanced much more rapidly than it did.

Toward the end of the Middle Ages, people became interested in sorting out facts and writing them down in an orderly way. The scholastics had few new ideas, but they rediscovered the writings of Aristotle and other ancient philosophers. They wrote long works on these ancient writings. These works were called **summas**, or summaries, and they resembled encyclopedias. From this scholastic movement came the people who began the rebirth of science, art, and true learning in general. This rebirth is called the **Renaissance**.

Match these items.

1.17 ________ barbarians

1.18 ________ Moors

1.19 ________ alchemy

1.20 ________ scholastics

1.21 ________ summas

1.22 ________ base metal

a. a combination of science and magic

b. any metal less valuable than gold

c. wrote summaries of ancient writings

d. overran the Roman Empire

e. summaries of ancient writings

f. tried to conquer Europe

g. philosophers of the ancient world

Explain this statement.

1.23 If the Moors had overrun Europe, Western science might have advanced more rapidly.

____

____

____

____

Renaissance science. This period of history saw a reawakening of true learning and original thought. The scholastics of the later Middle Ages really borrowed most of their ideas from ancient philosophers, but the people of the Renaissance produced new ideas and inventions.

One of the most important pronouncements of the Renaissance was that made by Nicolaus Copernicus. Copernicus was a Polish mathematician and astronomer. He stated the **theory** that the earth is not the center of the universe as the Roman Catholic Church had taught for centuries. He believed the sun to be the center around which the planets revolve. He also maintained that the earth rotates on its axis. This statement was contrary to the prevailing idea that the earth was absolutely still.

Copernicus was loyal to the Roman Catholic Church and so refrained from pushing his revolutionary ideas. His successor, however, was not so quiet. Galileo Galilei was also an astronomer. He studied the heavens through the telescope that he made and came to the conclusion that Copernicus was correct in his theory.

Galileo published a paper stating his findings. The Roman Catholic Church forced him to take back what he said. Even though he recanted, he was imprisoned and was watched closely for the rest of his life. Despite his lack of moral courage to stand up for what he believed, Galileo gave the world a valuable tool with which to work: the knowledge that the planets revolve about the sun and that the earth turns on its axis.

Another scientist of the Renaissance was Sir Isaac Newton. He studied the work of Galileo and figured mathematically that any two bodies of matter in the universe attract each other with a certain force. We call this principle or **law**, the *Law of Universal Gravitation*.

These individuals contributed a great fund of scientific fact upon which modern science is built. The Renaissance merges gradually with modern times. Numerous scientists cannot be classified as strictly Renaissance, but they are not truly modern either. We will study one or two of them in the next section.

Complete these sentences.

1.24 A period of history that saw a reawakening of true learning is called the ________________ .

1.25 A Polish mathematician and astronomer who stated that the earth was not the center of the universe was ________________ .

1.26 ________________ agreed with Copernicus that the earth is not the center of the universe.

1.27 The attraction between any two objects is described by the Law of ________________ .

1.28 The law referred to in 1.27 was formulated by ________________ .

Post-Renaissance science. Great numbers of new discoveries were made during the Renaissance. Building on these discoveries, the people of the post-Renaissance period formulated theories in various fields.

In the field of the physical sciences (chemistry, physics, and astronomy), John Dalton formed a theory based in part on the work of Democritus. Dalton's atomic theory stated that atoms are tiny, solid spheres which, like Democritus' atom, are indivisible. We now know that atoms are not what Dalton thought, but his work started people thinking about atoms once more.

The field of the biological sciences had many representatives at this time. Scientists were curious about how traits or characteristics are passed from parents to their offspring. They were also curious about how the various types of plants and animals came to be the way they are. These ideas were common at this time because people were questioning the Bible as absolute truth. Some even denied the existence of God, at least as Creator and Controller of the universe. Since they did not accept God's Word, they believed they had to develop a new explanation for the origin of plants and animals. Although this view of life has led to disastrous results, some good ideas have come from it also.

Jean Baptiste de Lamarck (1744-1829) was a French biologist of this period. His theory was accepted as fact for many years and still is thought to be true by some people. He stated that some characteristics which **organisms** acquire after they are born can be passed on to their offspring. The example Lamarck's theory puts forth is the giraffe. In theory, the giraffe once had a short neck, but its need to stretch to reach higher and higher branches caused its neck to become longer. Each generation of giraffes had longer necks than the generation before, resulting in the modern giraffes which have very long necks. Scientists have proved this theory false repeatedly, but some people still insist on believing such statements as these:

> *"The snake didn't use its long legs, so it gradually lost them."*
>
> *"Well, I know she's been here since she was a baby, but all Asians like rice. It's inherited."*
>
> *"I know my little boy has a weak right arm because I broke mine playing baseball when I was fifteen."*

These statements are not based on fact; however, a large number of people hold that they are true.

Another scientist interested in inheritance was Charles Darwin. He formulated the theory of **evolution** which states that all present-day **species** (types) of plants and animals developed over a long period of time from a few simpler ancestors. In the past 120 years Darwin's theory has been expanded and explained. It now is the basis of most other sciences, as well as biology. Evolutionists now say that all creatures began as microscopic organisms. Darwin's theory and its additions have had a serious impact on the world, but Christians do not accept his theory. First, the Bible teaches an entirely different beginning of life. Second, if human beings gradually evolved from some lower form of life, there was no garden of Eden, no temptation, no Fall. Thus, there is no sin nature in each individual, and Jesus Christ died for no reason. For these reasons, the theory of evolution is treated as just that—*a theory*, which attempts to explain creation without a Creator.

A good representative of the period just preceding modern science of the twentieth century is Louis Pasteur. Pasteur studied the action of microscopic organisms and demonstrated that they can cause disease. He developed a process of *pasteurization* by which harmful organisms in certain foods (for example, milk) can be killed. He also developed a vaccine for rabies.

The people that have been mentioned are only a few of those scientists who gave us useful ideas without which the scientific world of today could not function.

Answer true or false.

1.29 ____________ Dalton said the atom was a solid particle.

1.30 ____________ It is possible to inherit a broken arm from your parents.

1.31 ____________ Darwin's theory states that all animals come from stones.

1.32 ____________ Lamarck's theory is still held to be true by some people.

1.33 ____________ Pasteur's theory is called the theory of evolution.

1.34 ____________ Pasteurization kills microscopic organisms.

1.35 ____________ Microscopic organisms can cause disease.

Answer this question using any encyclopedia.

1.36 Who was Gregor Mendel, and what did he discover? (Use full sentences and good paragraphs. Write this exercise on a separate piece of paper.)

TEACHER CHECK ____________ ____________
initials date

Modern science. In the twenty-first century both science and invention have progressed at a fantastic rate. Within the lifetime of one individual, the world has moved from the horse and buggy to supersonic jets and space stations. So many people have contributed to this expansion that it is difficult to choose those who are representative of them all.

Just before the turn of the century a woman, Marie Curie, made a discovery which has had results beyond anything she could have imagined. She left some unexposed film in a dark drawer with a piece of pitchblende, a substance containing radium. The radium gave off what we now call *radiation* which exposed the film. From this observation have come the study of x-rays and our modern atomic theory, among other things.

One of the most famous men of this century was Albert Einstein. He was both a mathematician and a scientist. He discovered the relationship between energy and matter, expressed in the well-known equation $E = mc^2$. This equation is read *energy equals mass times the square of the speed of light.* It means that if a small amount of matter is totally destroyed in a nuclear reaction, a tremendous amount of energy will be released. This theory has given rise to nuclear weapons as well as to the hope for useful energy from atoms.

While Einstein was forming his ideas, another scientist, Niels Bohr, was developing a theory of atomic structure. He said that the atom has a dense center containing positively charged **protons** and neutral **neutrons**. Around this center, he believed, are orbits of varying sizes along which negatively charged electrons travel. Since Bohr's time, his atomic model has been subjected to many revisions, but he was surprisingly close to what seems to be the actual structure of the atom.

In the field of medicine, one of the most significant researchers was Dr. Jonas Salk. He and his staff developed a vaccine which prevents **poliomyelitis**, or simply polio. Because of his work, many people who might have been crippled or might have died have been spared this terrible disease.

Each of these people contributed valuable information to modern science, and others are continuing to do the same. We owe a great debt to these men, but we should remember that they are only men. They are not God. They can and do make mistakes. Let us rely on God alone and trust His wisdom. If we do so, we will never depend too much on weak human beings however great they seem to be or whatever marvelous things they have accomplished.

Answer these questions using complete sentences.

1.37 What did Marie Curie discover? ____________________

____

1.38 What does $E = mc^2$ mean? ____________________

____

1.39 Why should we rely on God rather than on men? ____________________

____

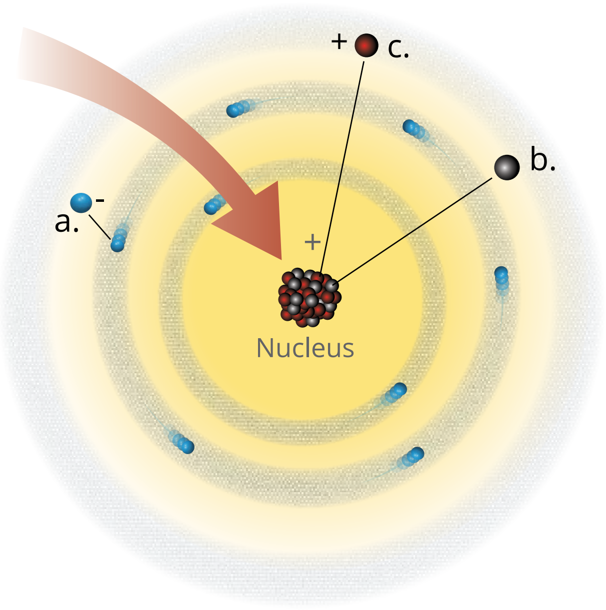
Complete this activity.

1.40 Label this atom.

a. ________________

b. ________________

c. ________________



Match these people with what they have discovered.

1.41 ________ Salk

1.42 ________ Einstein

1.43 ________ Bohr

1.44 ________ Curie

a. atomic structure

b. radiation

c. transistors

d. E = mc^2

e. evolution

f. polio vaccine

THE SCIENTIFIC METHOD

For a scientist to work effectively, it is necessary that he follow a system of steps as he approaches each new problem. Variations on this system of steps have been composed, but they all cover the same procedures. The nine steps of the **scientific method** in this LIFEPAC may be somewhat different from the steps you have seen somewhere else, but you will find that the same basic order is followed.

The first step is, of course (1) to *choose a problem*. This step seems simple; but when you try it, you find it can be surprisingly involved. The problem must be one that you have the ability to solve, one that interests you, and one that is worth the time to solve. Some problems are so unimportant that you would be wasting your time trying to solve them.

The second step is (2) *to state what you think is the probable solution to the problem*. This probable answer is called a **hypothesis**.

When you have stated a hypothesis, you must (3) *research what other scientists have done* to solve your problem or other similar ones. You may find that someone else has already solved your problem, or you may find that another's research will simplify your work.

Having collected all the information you can, you (4) *experiment to prove or disprove your hypothesis*. It is sometimes necessary to repeat these experiments again and again.

If your hypothesis is correct, (5) *state it again as a theory*. A theory is more sure than a hypothesis, but it has not been tested enough to prove it beyond all doubt.

Should your hypothesis be in error, you must (6) *state a new hypothesis and start over again*.

When you have proved your hypothesis enough to state it as a theory, you (7) *write a paper on what you did to prove it*, and you publish your paper in a scientific journal.

Sometimes new facts will be discovered which prove a theory wrong. Always keep enough doubt in your mind about your theory that you can (8) *change it* should it be proved wrong.

If after many years a theory has been shown by repeated tests to hold true every time, (9) *the theory is stated as a law*.

An example of a scientist using the scientific method is Sir Isaac Newton. His hypothesis was that all bodies of matter attract one another with a certain force. The attraction, he thought, would be smaller the farther apart the bodies were. Newton studied the works of other scientists on this subject. He decided to do a mathematical test using the data about the moon and the earth. When he had finished his experiments, his hypothesis was found to be true. It was then a theory: The Theory of Universal Gravitation. Over many years this theory has never once been disproved, so it has acquired the status of a law: *The Law of Universal Gravitation*.

Remember, for scientific work, always follow these or similar steps. Without them your work will be unreliable, because it will be neither orderly nor conclusive.

Write the nine steps of the scientific method in order.

1.45 ____

1.46 ____

1.47 ____

1.48 ____

1.49 ____

1.50 ____

1.51 ____

1.52 ____

1.53 ____

Write the following steps in their proper order.

a. The rats died.
b. Similar substances have killed rats.
c. A certain substance will kill a rat.
d. State the theory of Rat-Kill.
e. Give the substance to many rats.
f. State the law of Rat-Kill.
g. Publish a paper.

1.54 ____

1.55 ____

1.56 ____

1.57 ____

1.58 ____

1.59 ____

1.60 ____

Answer this question.

1.61 Why is it important to use some form of the scientific method? ____________________

____

____

SCIENTIFIC MEASUREMENT

Three kinds of scientific measurement will be presented in this section: (1) the metric system (2) scientific notation, and (3) significant figures.

The scientist works with numbers almost as much as a mathematician does. Measurement and figuring are a vital part of science. To make mathematics as simple as possible, the scientist uses the **metric system** almost exclusively.

For our purposes the metric system has three units that are *defined*; all other units are *derived* from these defined units. The standard units are:

length...........	the meter
mass.............	the kilogram
time..............	the second

Each unit has divisions and multiples, just as an inch is a division of a foot; and a yard is a multiple of a foot. The metric system is simpler to use, however, because its divisions and multiples are all based on the number ten. Here are a few commonly used examples, with the standard unit shown in **boldface**.

Defined Units

Length

1000 meters = 1 kilometer (km)

1 meter (m) is the standard unit

0.01 meter = 1 centimeter (cm)

0.001 meter = 1 millimeter (mm)

Mass

1000 grams = 1 kilogram (kg)

1 gram (g) is the standard unit

0.001 gram = 1 milligram (mg)

Time

60 seconds = 1 minute

1 second is the standard unit

0.001 seconds = 1 millisecond (ms)

(Multiples of seconds are not based on the number 10)

Derived Units

Units of volume are *derived* units, but they follow the same pattern. You will be working with metric units all the time, so learn them well. They are necessary tools of the scientist.

Volume

1000 liters = 1 kiloliter (kL)

1 liter (L*) is the standard unit

0.01 liter = 1 centiliter (cL)

0.001 liter = 1 milliliter (mL)

**The National Bureau of Standards (spring, 1978) has standardized the abbreviation of liter as L (with no period).*

Scientific Units

Complete these sentences.

1.62 The metric system is based on the number ____________________ .

1.63 The meter, the kilogram, and the second are (defined, derived) ____________________ .

1.64 The liter is a (defined, derived) ____________________ unit.

1.65 If 1 centimeter equals 10 millimeters, what does 2 centimeters equal?

2 centimeters = ____________________ millimeters

1.66 A ____________________ equals 1,000 milligrams.

Answer these questions.

What do these prefixes mean?

1.67 kilo- ________________________

1.68 centi- ________________________

1.69 milli- ________________________

Scientific notation. Sometimes scientists must work with very large numbers. To make their work easier, they use a kind of mathematical shorthand called **scientific notation.** Do not allow the long name to stop you. The system is not so difficult as its name would lead you to believe. Like the metric system, it is based on the number 10.

To write a number in scientific notation begin by writing the far left digit. Let us use the number **200** as a model:

First write the 2.	Then write a multiplication sign.	Then write the number 10.
2	2 •	2 • 10
Then count the number of digits after the 2 in 200. There are two zeros. Place a small 2 up to the right of the 10. This 2 is the **exponent**.		
$2 \cdot 10^2$		

This mathematical expression is read *two times ten to the second power or ten squared.* Scientific notation is writing a number less than ten times a power of ten.

Scientific Notation

To write in scientific notation a number that has more than one digit which is not a zero is a little more involved. Use the number **528** as a model.

First write the far left digit.	Then place a decimal point after the 5.	Then write the other two digits in order.	Then add the multiplica-tion sign and the 10
5	5.	5.28	5.28 • 10
Now, count the number of digits after the decimal point in 5.28. There are two of them, 2 and 8; therefore, place a small 2 up to the right of the 10.			
5.28 • 10^2			

We read this sentence as five and *twenty-eight hundredths times ten squared.* (Often we use a short cut and say *five point two eight times ten squared*).

A number having more than three digits is read slightly differently. For example, the number 1,248 would be written 1.248 •10^3. It is read *one point two four eight times ten to the third power or ten cubed*. The number 48,691 is written 4.8691 · 10^4 and would be read *four point eight six nine one times ten to the fourth power.*

What happens if the number already has a decimal like **7564.2**? As with the others you begin with the far left digit.

Write the 7 and place a decimal after it.	Then write the other digits in order, add a multiplication sign and the ten.
7.	7.5642 • 10
Then count the number of digits between the new decimal position and the original. The decimal has been moved three places so 10 has an exponent of 3.	
7.5642 • 10^3	

The exponent in scientific notation always tells you how many places the decimal point has to be moved to get back to the original number.

Numbers having only one or two digits are not written in scientific notation.

To work back to numerals from one written in scientific notation is not difficult. For instance, consider **4 • 10^5** as a model.

First write the digit 4.	Then look at the exponent of ten; it is 5, so write five zeros to the right of 4.	Now count back 3 zeros from the right and place a comma.
4	400000	400,000

The number is four hundred thousand.

Scientific Notation

Again, consider the number $6.2 \cdot 10^4$. This model is a bit different, so follow the steps carefully.

First write the 6.	Now look at the exponent of ten. It is 4. A total of four digits will be written to the right of the six. The 2 is the first of the four. Now add three zeros to complete the four digits.
6	62000
Next, count back three digits from the right and place a comma.	
62,000	

The number is sixty-two thousand.

Following these simple steps, you should be able to write any numeral in scientific notation and change any scientific notation back to a numeral.

Scientific Notation

Write these numerals in scientific notation.

1.70 430 ______________

1.71 6,282 ______________

1.72 50,000 ______________

1.73 285 ______________

1.74 7,960 ______________

Write the scientific notation in numerals.

1.75 $5 \cdot 10^3$ ______________

1.76 $3.23 \cdot 10^3$ ______________

1.77 $5.82 \cdot 10^3$ ______________

1.78 $1.2 \cdot 10^4$ ______________

1.79 $6.4 \cdot 10^7$ ______________

TEACHER CHECK ______________ initials ______________ date

Significant figures. To be accurate with scientific measurements all figures should be as close to correct as possible. Whenever you measure or figure, you arrive at an answer in digits. The answer may have one digit or many. The digits we are sure of are **significant figures**. A number will always have at least one significant figure unless it is only a guess, in which case the number is written in words.

Every number is composed of digits. For example, consider 6,432 centimeters. The last number, 2, shows that the object is at least 6,431 centimeters and not more than 6,433 centimeters. The 2 is not as sure as the 6, 4, and 3; it is approximate. the number 6,432 has *four significant figures*, but the last one is only approximate. If we wanted to show that the last digit was absolutely certain, we would write 6,432.0.

In a number ending in zeros, the zeros are not counted as significant figures. They are simply place holders, unless they are to the right of the decimal. For example 7.600 has four significant numbers while 0.0077 has but two. The number 0.00770 has three.

In the number 5,690 the 5, the 6, and the 9 are the significant figures. The zero merely fills the ones' place.

If zeros come directly after the decimal and before the other digits, they are not significant figures, but place holders. The number 0.0062 has only 2 significant figures: the 6 and the 2. The zeros are place holders only.

Scientists often work with several large numbers at one time. Perhaps a scientist needs to add a list of quantities. Note this problem:

6.09 grams
5.38 grams
7.22 grams
4.1 grams
18.623 grams
+ 5.2648 grams
46.6778 grams

The answer is 46.6778 grams, but how much of that answer can be considered reliable?

Well, just as a chain is only as strong as its weakest link; so an answer is only as accurate as its least accurate component. The number from the list of quantities with the fewest significant figures is 4.1. It has only one significant figures right of the decimal point. Thus, the answer 46.6778 is accurate only to one decimal place. The accurate answer would be rounded off to 46.7.

How many significant figures does each of these numbers have?

	Significant Figures	
1.80	____________	18.20
1.81	____________	2.4
1.82	____________	83.400
1.83	____________	12
1.84	____________	.00000004
1.85	____________	6,253.862

Round these numbers to two significant figures.

1.86 634 ________________

1.87 5,206 ________________

1.88 72.8 ________________

1.89 8,468 ________________

Write these totals to the correct number of significant figures.

1.90

```
  8.3
  5.2
  4.36
 42.1
+ 86.0
```

____

1.91

```
  28
  42
   6
+ 931
```

____

1.92

```
  6.8321
+ 7.5248
```

____

1.93

```
   2
   1
+ 5.3
```

____

1.94

```
  1.2
  2.2
  3.6
  5.1
+ 0.2
```

____

View 801 Accuracy in Measurement, from the Grade 8 SCIENCE EXPERIMENTS Video

NOTE: The Grade 8 SCIENCE EXPERIMENTS Video is a suggested resource for this course.

Try this investigation.

These supplies are needed:

- graduated cylinder
- water
- ruler with cm and mm markings
- balance (triple-beam or other type)

To use measurement well, one must practice using it. You will need a ruler at least 10 centimeters long.

a. ______ b. ___ c. ____________

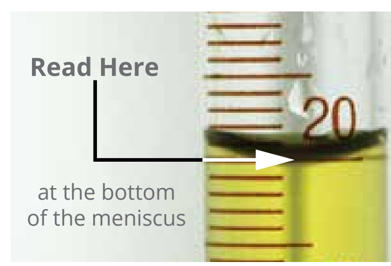
1.95 line a. __________ cm **1.96** line b. __________ cm **1.97** line c. __________ cm

Measure each of these lines to the nearest millimeter.

a. _ b. ___ c. _________

1.98 line a. __________ mm **1.99** line b. __________ mm **1.100** line c. __________ mm

Now, get a graduated cylinder marked in milliliters(ml). You will need an older student, your teacher, or your parent to check these exercises.



Fill the cylinder to these amounts.

1.101 10 milliliters **1.103** 22 milliliters

1.102 5 milliliters **1.104** 18 milliliters

Use a balance (triple-beam or other type) to find the mass of these items.

1.105 a shoe **1.106** a paper cup **1.107** a large dictionary

______________ g ______________ g ______________ g

TEACHER CHECK __________ initials __________ date

Accuracy in Measurement Experiment

Write each numeral in scientific notation.

1.108 ______________________ 82

1.109 ______________________ 1,263

1.110 ______________________ 1,000,000

1.111 ______________________ 541

1.112 ______________________ 2,000,004

1.113 ______________________ 106.3

1.114 ______________________ 820.5

Write these scientific notations in numerals.

1.115 ______________________ $4.1 \cdot 10^2$

1.116 ______________________ $5.0 \cdot 10^{10}$

1.117 ______________________ $1.83 \cdot 10^5$

1.118 ______________________ $1.5463 \cdot 10^3$

1.119 ______________________ $9.62548 \cdot 10^4$

Tell how many significant figures each of these numbers contains.

1.120 __________ 94

1.121 __________ 80

1.122 __________ 1.23

1.123 __________ 5,684

1.124 __________ 9,843.6

Follow these directions.

In these problems write C if the total is written with the correct number of digits and is rounded correctly. Write I if the total has the wrong number of significant figures or if the number has not been rounded correctly.

1.125

```
  8
  6
  5
+ 1
 20
```

____

1.127

```
   22.1
   43.20
   86.1221
 + 91.56
  242.9
```

____

1.126

```
  4.2
  6.11
+ 8.5
 18.81
```

____

1.128

```
   2.11
   5.83
   7.64
  10.5
 + 8.33
  34.4
```

____

Write each of these numbers showing three significant figures.

Remember to round them.

1.129 ______________________ 8.428

1.130 ______________________ 90,862

1.131 ______________________ 566

1.132 ______________________ 10,411

Write each of these numbers to two significant figures in scientific notation.

1.133 ______________________ 482.65

1.134 ______________________ 8,421,032.9266

1.135 ______________________ 5,489.6654

1.136 ______________________ 4.253

TEACHER CHECK ____________ initials ____________ date

NOTES

Review the material in this section in preparation for the Self Test. The Self Test will check your mastery of this particular section. The items missed on this Self Test will indicate specific areas where restudy is needed for mastery.

SELF TEST 1

Complete these statements (each answer, 3 points).

1.01 Science is orderly ______________________ .

1.02 Trying to demonstrate a fact by testing to see if the same result occurs repeatedly is ______________________ .

1.03 A Greek who tried to develop a systematic classification for plants and animals was ______________________ .

1.04 Alchemists tried to turn base metals into ______________________ .

1.05 A probable answer to a scientific problem is a ______________________ .

1.06 The rebirth of science and learning of the fifteenth century is termed the ______________________ .

1.07 Copernicus hypothesized that the ______________________ is not the center of the universe.

1.08 The Law of Universal Gravitation was discovered by ________________ .

1.09 ______________________ formulated the theory of evolution.

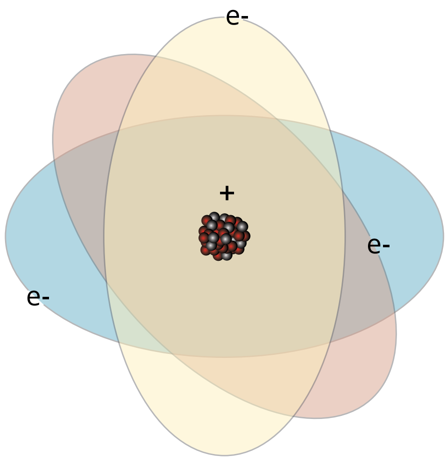
1.010 Louis Pasteur demonstrated that ______________________ can cause disease.

Match these terms (each answer, 2 points).

1.011 _______ Lamarck
1.012 _______ Curie
1.013 _______ Dalton
1.014 _______ Salk
1.015 _______ Einstein

a. polio vaccine
b. inheritance of acquired characteristics
c. $E = mc^2$
d. tiny, solid, spherical atoms
e. evolution
f. radiation

Circle the best answer (each answer, 2 points)



1.016 This diagram is an illustration of ________________ .
a. a microorganism b. a cancer cell c. an atom

1.017 A theory that has been proved true many times is called ______________ .
a. evolution b. a law c. a guess

1.018 That every object attracts every other object is ______________________ .
a. the Law of Universal Gravitation
b. untrue
c. the Law of Affinity

1.019 Protons, neutrons, and electrons are part of _______________________ .
a. the atom b. a polio vaccine c. Pasteur's discoveries

1.020 When matter is destroyed in a nuclear reaction, _____________________ .
a. a small amount of energy is absorbed
b. a small amount of energy is released
c. a large amount of energy is released

Solve these problems (each answer, 4 points).

1.021 1,000 _______________ = 1 liter.

1.022 Write 4,142 in scientific notation _______________________________ .

1.023 Write $5.2 \cdot 10^3$ in numerals _________________________________ .

1.024 Add and round to the correct number of significant figures.

6.3
8.2
5.43
<u>9.671</u>

____

1.025 How many significant figures does the number 6.640 have? _____________

56/70	SCORE ____________	TEACHER ____________ initials	____________ date

SCI0801 – May '14 Printing

ISBN 978-0-86717-771-8

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Alpha Omega
PUBLICATIONS

804 N. 2nd Ave. E.
Rock Rapids, IA 51246-1759

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www.aop.com