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[Caption] This video is closed captioned.

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INTRODUCTION

Matter: Atoms and Molecules is part of the Elements of Physics Series, a six-part series of programs to help students understand fundamental concepts of physics. The attractive images and engaging narration of the program have been designed by educators and filmmakers to help students understand the sometimes complex and often obscure scientific explanations of our physical world.

As long ago as the ancient Greeks, there was speculation that tiny particles were the smallest units of matter, but little more than 100 years ago physicists learned that the atom was the fundamental unit of all matter. This program explores the structure of atoms and molecules. It provides a comprehensive introduction to our understanding of matter and explains some of the major discoveries of this exciting field.

LINKS TO CURRICULUM STANDARDS

Elements of Physics Series is based on the "National Science Educational Standards" for "Physical Science," grades 9-12, (Content Standard B).

STUDENT OBJECTIVES

After viewing the program and participating in the various follow up activities students should be able to do the following:

• Describe the basic structure of all atoms, including protons, neutrons, and electrons.

• Explain how electricity binds atoms together.

• Give an explanation of the "planetary model" of the atom and the "uncertainty principle."
• Provide a general description of the sub-atomic particles of quarks.

• Describe elements and the differences between elements.

• Give an explanation of "atomic number" and "atomic weight."

• Explain the importance of the shells of atoms and how the stability and activity of electrons depends on whether or not the shells are full.

• Show how the periodic table helps us understand the elements and their relationships.

• Describe how atoms combine to form molecules.

• Explain how most elements and substances can exist as a solid, a liquid, or a gas.

### SUMMARY OF THE PROGRAM

All matter in the universe is made up of tiny atoms and each atom has a similar structure. Atoms are made up of a nucleus of protons and neutrons and around the nucleus spin electrons. The force that binds atoms together is electricity. Electrons have a negative electrical charge and protons have a positive charge. Opposite electrical charges attract each other and it is that attraction that holds the electrons in their orbit around the nucleus.

Atoms are incredibly small, but recent research has shown that there are particles that are even smaller. Protons and neutrons are made up of tiny particles called quarks. All atoms have common characteristics but there are different types of atoms with varying numbers of electrons, protons, and neutrons. An atom with a unique number of protons is called an element. In total there are 92 elements found naturally in the universe and about 20 more that have been created in laboratory conditions.

An element is an atom with a particular number of protons in its nucleus. The number of protons in its nucleus determines the
atomic number of the element. In most cases atoms have the same number of protons, neutrons, and electrons, but some atoms have a different number of neutrons than protons. They are called isotopes. When an atom gains or loses an electron, it is called an ion.

The number of electrons that circle the nucleus determines the physical and chemical properties of the atom. The electrons circle the nucleus in irregular patterns called orbitals. The stability and activity of the atom depend on whether the shells are full or not. The periodic table is a type of map that helps scientists understand the way groups of elements with different types of properties interact with each other.

Atoms sometimes remain alone, but often they combine with other atoms to create molecules, which make up the millions of substances in the universe. The atoms combine by sharing the electrons in their outer shells. What holds the molecules together are the electrical charges between the electrons and the nuclei. When atoms combine into molecules they can take on characteristics much different than their constituent elements.

Almost all elements can exist as a solid, a liquid, and a gas, depending on the temperature or pressure. When a substance is a solid, the atoms are compact; when it is a gas, the atoms are much looser; and when it is a liquid, they are somewhere between these two extremes.

Intense research continues in the areas of atoms, sub-atomic particles, and the molecular structure of compounds, but many of the mysteries surrounding the fundamental make up of matter have been unraveled.

**PRE-TEST AND POST-TEST**

Blackline Master #1, Pre-Test, is an assessment tool intended to gauge student comprehension prior to viewing the program. Remind your students that these are key concepts upon which they should focus while watching the program.
Blackline Master #7, Post-Test, can be compared to the results of the Pre-Test to determine the changes in student comprehension after participation in the activities and viewing the program.

**TEACHER PREPARATION**

Before presenting this program to your students, we suggest that you preview the program and review this guide and accompanying Blackline Master activities in order to familiarize yourself with the content. Feel free to duplicate any of the Blackline Masters and distribute them to your students.

As you review the materials presented in this guide, you may find it necessary to make some changes, additions, or deletions to meet the specific needs of your class. We encourage you to do this. Only by tailoring this program to your class will your students obtain the maximum instructional benefits afforded by the materials.

We suggest that you first show the program in its entirety to your students. This is an introduction to the complex subject of matter, and at this stage it is helpful that students gain an overview of the concepts and material in the program. A number of lesson activities will grow out of the content of the program and, therefore, the presentation should be a common experience for all students.

After the introduction the program is divided into chapters with the following titles:

- The Atom
- The Elements
- The Periodic Table
- Molecules
- Common Phases of Matter

These chapters vary in length from three to five minutes. After the students have seen the entire program, lessons could be designed around these different chapters. A chapter could be shown at the beginning of the class, and the balance of the class
time and subsequent classes, could be spent examining the subject matter in the program in greater depth.

**STUDENT PREPARATION**

It is important that students work through the material and familiarize themselves with the vocabulary, concepts, and theories that scientists use to understand this field.

If the students have a textbook that they are following, assign the relevant reading before the lesson. As students work through the material, they will encounter a number of unfamiliar words and concepts. Most of these words are highlighted in the program. An additional list of words is provided in **Blackline Master #2a-c, Vocabulary Definitions and Activities**.

The program concludes with a 10-question Video Quiz that may be used to gauge students' comprehension immediately after the presentation of the program. **Blackline Master #6, Video Quiz**, is a printed copy of the questions, which may be reproduced and distributed to the students. The answers to the questions appear in the answer key of this Teacher's Guide.

**DESCRIPTION OF BLACKLINE MASTERS**

**Blackline Master #1, Pre-Test**, should be given to students before viewing the program. When these answers are compared to the Post-Test results, it will help you gauge student progress.

**Blackline Master #2a, Vocabulary Definitions**, will introduce students to unfamiliar words and concepts used in this program. **Blackline Master #2b, Use the Right Word**, and **Blackline Master #2c, Word Match**, are activities designed to help reinforce key concepts and vocabulary.

**Blackline Master #3, Connected Not Connected**, will help students identify their knowledge of key vocabulary terms and the context in which they are used.

**Blackline Master # 4, Crossword Puzzle**
Blackline Master #5, Creative Writing Story Ideas, will allow students to think creatively while incorporating scientific principles and vocabulary covered in this program.

Blackline Master #6, Video Quiz, is a printed version of the Video Quiz that appears at the end of the program.

Blackline Master #7, Post-Test, may be used to evaluate student progress after completing this lesson.

**ANSWER KEY**

Blackline Master #1, Pre-Test
1. true
2. true
3. false
4. true
5. false
6. true
7. true
8. false
9. true
10. false

Blackline Master #2b, Use the Right Word
1. matter
2. electrons
3. positive
4. quarks
5. orbitals
6. element
7. valence
8. ion
9. periodic table
10. compounds
**Blackline Master #2c, Word Match**

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>atom</td>
<td>fundamental unit of all matter</td>
</tr>
<tr>
<td>electron</td>
<td>negatively charged particle</td>
</tr>
<tr>
<td>elements</td>
<td>different types of atoms</td>
</tr>
<tr>
<td>gases</td>
<td>vaporous form of matter</td>
</tr>
<tr>
<td>matter</td>
<td>physical substances or material</td>
</tr>
<tr>
<td>molecules</td>
<td>compounds of two or more atoms</td>
</tr>
<tr>
<td>particles</td>
<td>sub-atomic structures</td>
</tr>
<tr>
<td>periodic table</td>
<td>an arrangement of elements</td>
</tr>
<tr>
<td>proton</td>
<td>positively charged unit in the nucleus of an atom</td>
</tr>
<tr>
<td>quark</td>
<td>particles that make up protons and neutrons</td>
</tr>
</tbody>
</table>

**Blackline Master #3, Connected/Not Connected**

1. protons neutrons
2. electrons nucleus
3. quarks leptons
4. atoms electricity
5. isotopes ions
6. planetary model planets
7. periodic table elements
8. positive negative
9. gases liquids
10. hydrogen uranium
Blackline Master #4, Crossword Puzzle

Blackline Master #6, Video Quiz

1. true
2. atoms
3. true
4. false
5. true
6. 92
7. false
8. true
9. compounds
10. true
Blackline Master #7, Post-Test
1. atoms
2. electricity
3. sub-atomic
4. isotopes
5. false: An ion is not a neutral atom. If an atom has one or more electrons than protons, it has a negative charge. If it has fewer electrons than protons, the atom has a positive charge.
6. true
7. false: The motion, position, and velocity of electrons cannot be predicted accurately. All that can be done is to give an approximation of their location. This is called the "uncertainty principle."
8. false: Electrons are sub-atomic particles called leptons. Electrons orbit the nucleus of atoms.
9. true
10. Although there are a great variety of animate and inanimate things in the universe they are all composed of matter or they are forms of energy. Living things, such as human beings have can reproduce, and metabolize energy, but they are still composed of matter and have energy.
11. Atoms have a natural tendency to combine with other atoms in order to fill their shells and become stable. If the shells of an atom like helium and neon are full, they are very stable and will not combine with other atoms, but if they are missing electrons in their outer ring or have extra electrons, they have unstable chemical properties and will tend to join other atoms.
12. Atoms join with other atoms and become molecules by sharing the electrons in their outer shells. Many molecules are very complex with dozens or even billions of different atoms. It is molecules that provide the great variety of chemical structures that make up the many different substances we find in the universe.

DISCUSSION QUESTIONS

1. If all matter is made up of atoms, is there a significant difference between living things and inanimate objects?
This is a religious, as well as a scientific, question and can be answered in many ways. A physicist, who takes a strictly materialist view of things, might answer there are only two things in
the universe: matter and energy. Living things are no different than inanimate objects. A biologist would disagree. He or she would point out that living things have a life cycle. They can reproduce, metabolize energy, and so on. This is significantly different than inanimate objects. A religious person would disagree with the physicist even more strongly by saying that people have a soul and are ethical beings.

2. Electricity is the force that binds atoms together. Is this the same force that electrifies our homes, factories, and offices? Yes. Electromagnetism, along with gravity and the strong and weak nuclear forces, is one of the fundamental forces of nature. In the 19th century, physicists learned how to generate electricity and control it so that electricity could be used as a source of energy for a vast number of tasks. This achievement is one of the great triumphs of physics that has had an enormous impact on the modern world.

3. Chemists have learned to change the molecular structure of petroleum to create plastic products that have characteristics that are useful for a variety of products. Do you think chemists should be allowed to hold patents on these products and make a profit on their sale? There are two ways that this question can be answered. It can be argued that the chemist only rearranged the molecular structure of matter that already existed in nature. Why should he or she be given the right to profit from it? The counter argument, and one that is legislated in most countries, is that the development of new innovations is a benefit to everyone in society, and in order to stimulate and encourage innovation, patent protection is given to inventors allowing them the exclusive right to commercially exploit their inventions for a limited period of time. After that time, the invention is considered to be in the public domain and anyone can commercially exploit it without cost.

4. We have been able to use science to create a number of new products, but are there any limit to these innovations? New products were created long before the principles of chemistry and physics were understood. Glass, steel, brass, and many other products were produced centuries ago either by accident
or primitive experimentation. In the last 100 years, however, since science has understood the underlying principles of atoms and molecules, a proliferation of new products has been invented, but there are still major limitations to the invention of new materials. The only raw materials that inventors have to work with to produce new materials are the 92 elements found naturally in the universe. They can be combined in a vast array of different molecular structures, but new elements cannot be created.

5. If matter cannot be created or destroyed how is it possible to vaporize some types of material?
Many types of material seem to disappear over time. A pan of water sitting in the sun will soon evaporate. When living things die, their bodies soon deteriorate. However, this does not mean that the matter has been destroyed. The H₂O molecules of water in the pan have changed into a gas of H₂O drifting in the air that we cannot see. Living things deteriorate after they die and change form. The atoms that make up matter cannot be destroyed, but they can change their form and molecular composition.

EXTENDED LEARNING ACTIVITIES

The following activities and projects might prove useful to students studying the subject of matter, atoms, and molecules.

1. Create an illustration of the following atoms: hydrogen, oxygen, and gold.

2. Illustrate the structure of a water molecule, H₂O, showing the two hydrogen atoms and one oxygen atom.

3. Visit a research facility for the study of atomic and sub-atomic particles. Write a report describing the objectives and preliminary findings of one experiment that is taking place in the facility.

4. Study the periodic table and explain why certain elements like oxygen and hydrogen, or sodium and chlorine, tend to combine. Use your background in chemistry to help in this project.
5. Select three common materials like salt, iron, and brass. Research the chemical structure of each material and write a report giving a physical description of the material.

6. Research the relationship between the electric force that holds atoms together and the electricity that provides energy for light bulbs. Write and illustrate a report on your findings.

7. Select an element and draw a picture of the atom when it has a neutral electrical charge, when it is a positive ion, a negative ion, and when the atom is an isotope.

8. Visit an oil refinery and write a report describing how different petroleum products are made.

9. Visit a plastic factory in your community and discuss with the chemist, or other people knowledgeable about the manufacturing process, why the plastic resin they use is appropriate for the final product. Write a report on your findings.

10. Thirty years ago, automobiles were made almost entirely out of steel. Today plastics make up about 30% of the material in cars. What are the advantages and disadvantages of using plastics in automobiles? Is it possible to make a car entirely out of plastic? Write a research report for the chief engineer of the auto plant on the advisability of using plastics in cars.

REFERENCE LIST

There are many excellent books and websites dealing with matter that are appropriate for students and available in libraries. The following is a short list.

Books:


Internet Sites:

http://www.aapt.org
This is the website of the American Association of Physics Teachers, an organization of physics high school teachers. They also publish a magazine called The Physics Teacher.

www.physicscentral.com
This is the website of the American Physical Society, which has some 42,000 physicists as members. The site is written in a non-technical way appropriate for high school students. It features news, describes research, and also answers questions from students.

www.physicsclassroom.com
This excellent site for high school physics students provides tutorials on interesting topics and multi-media animations to help students visualize major physics topics.

www.nyu.edu/pages/mathmol/library/
This site provides models of various molecules such as water, hydrocarbons, amino acids, and many others. It also has excellent links to other web sites that will be of interest to high school science students.

www.whyfiles.org
This "fun" website is prepared by the University of Wisconsin. It changes every week and provides a number of interesting images. They claim to pack their site with "more personality and punch than you'd dare hope for."

www.fnal.gov/gov/pub/inquiring/matter
This is the web site of the Fereni National Accelerator Laboratory. It deals specifically with questions such as: what is matter? What is the world made of? And what are the smallest particles? This is a very interesting site for the self-directed student who craves more information.
MATTER: ATOMS AND MOLECULES
A deer, a dragonfly, a rock, and a tree. What do all of these things have in common? They are made up of matter. Lightning, the motion of a child on a swing, an explosion, and flowing molten metal. What do these things have in common? They are forms of energy.

Matter and energy are what make up the physical universe. At one time, physicists thought that they were completely different, but now it is known that matter and energy are very closely related.

This program will focus on matter, and describe how scientists understand the fundamental building blocks of our universe.

THE ATOM
"What is the smallest unit of matter?" has been a question that has been posed at least since the ancient Greeks, but it is only recently that a clear answer can be given. Physicists now know that atoms are the basic building blocks of all matter, living or non-living.

Each atom is made up of electrons that spin around a nucleus made up of protons and neutrons. The nucleus itself is made up of protons and neutrons, collectively called nucleons. Protons possess a positive electrical charge, and neutrons have no charge. Since electrical charges that are the same, repel each other, why is it that a nucleus does not fly apart? It is the strong nuclear force between the protons and neutrons that holds it together. The protons give the nucleus a positive charge. Despite its small size, the nucleus is very dense and contains most of the mass of the atom.

The protons and neutrons in the nucleus are actually made up of even smaller particles, called quarks. There are six different types of quarks, but only two occur in atoms. The others exist only in unstable particles. Quarks and electrons are considered to be the smallest units of matter in the universe.
The force that attracts the electrons to the nucleus and binds the atom together is the electromagnetic force. Opposite electrical charges attract each other and it is that attraction that holds the electrons in their orbits around the nucleus. The negative electrical charges of the electrons balance the positive electrical charges of the protons, making the atom electrically neutral.

If atoms were visible, the electrons would appear as a cloud, dense in some parts and thin in others. Early models of the atom compared the movement of the electrons to planets orbiting the sun, the so-called "planetary model." It is now known that the actual movement of electrons is much more complicated. Electrons spin, they have an electromagnetic charge, and are subject to the forces of gravity, but they also act like waves, moving together around the nucleus in complicated patterns called "orbitals."

Physicists have calculated mathematically where electrons are likely to be found, as they orbit the nucleus. This animation is a 3-D representation of those probability calculations. The brightest regions represent the highest probability of the electron's location and the darkest regions, the lowest probability. For different energy states of the electrons, the patterns of probability become more and more complex!

Experiments have proven that it is impossible to know both the precise location of an electron and its speed at the same time. This is known as the "uncertainty principle."

THE ELEMENTS
All atoms have certain common characteristics, but there are different types of atoms with varying numbers of electrons, protons, and neutrons. An atom with a unique number of protons is called an element. For example, all atoms having eight protons are oxygen atoms and those with 79 protons are gold atoms. In total, there are 92 elements that are found naturally in the universe, and about 20 more that have been created in laboratory conditions.

Hydrogen is by far the most prevalent element in the universe. It is also the simplest. It has one electron that orbits around a
nucleus that contains one proton. Hydrogen has the Atomic Number of one because it has one proton. Scientists around the world use the symbol of H as a convenient shorthand for Hydrogen. All of the elements have letter symbols. The symbol for Iron is Fe, and it carries the Atomic Number of 26 because it has 26 protons in its nucleus. To be electrically neutral, an iron atom must have 26 electrons. Every atom has its own atomic mass, the total mass of all the protons and neutrons in its nucleus, plus its electrons. Hydrogen is very light, while iron is relatively heavy, in relation to other elements.

The number of electrons that circle the nucleus determines the physical and chemical properties of each element. The electrons circle the nucleus in orbital patterns, which are arranged in different energy levels called shells. Each shell can have only a specific number of electrons. In the first shell, there can be a maximum of only two electrons, but the outer shells can accommodate more electrons. In the second and third shells, there can be a maximum of eight electrons. Shells four and five can have a maximum of 18, and shell six has a maximum of 32.

The stability and activity of the atoms depend on whether the shells are full of electrons or not. The electrons in the outer shell are called the valence electrons. If that outer ring of valence electrons is full, the element is very stable, but if it is not full, then the element has the tendency to join with other atoms. For example, an oxygen atom has eight electrons. The first shell of the atom has two electrons and the second shell has six electrons. But the second shell could take up to eight electrons. As a result, the oxygen atom is somewhat unstable. A neon atom, on the other hand, has ten electrons. Two are in the first shell and eight in the second shell. The second shell is full and this makes the neon atom very stable. Neon is one of the noble gases and all of the noble gases are extremely stable because their outer shells are completely full of electrons.

All atoms of an element, for example carbon, contain the same unique number of protons but sometimes the number of neutrons in the nucleus varies. These are called "isotopes." Carbon-12 has six protons and six neutrons. Carbon-13 is an isotope with six protons and seven neutrons, and carbon-14 is
an isotope with six protons and eight neutrons. Isotopes have nearly identical chemical properties of the elements they are related to. They carry the same atomic number but have a different atomic mass.

When an atom has the same number of electrons and protons it has no electrical charge because the positive and negative charges balance, but electrons can move from atom to atom. If an atom loses an electron, it will have a positive charge because the protons outnumber the electrons. If it gains an extra electron, the atom will have a negative charge. Atoms such as this are called "ions."

THE PERIODIC TABLE
This is the periodic table. It is a type of map that helps us understand the elements and their relationship to each other. The table is arranged in a repeating pattern of columns and rows, which group elements together, based on their chemical characteristics.

All of the elements are listed by atomic number, that is the number of protons in the nucleus, from hydrogen, with an atomic number of one, to uranium with an atomic number of 92. The table even goes beyond uranium to what are called the "transuranium elements" that have been created in the laboratory but do not occur naturally.

The number under the symbol for the element is its atomic mass. The atomic mass increases as the atomic number increases. That is because the more protons, neutrons, and electrons there are, the greater the mass of the atom and the heavier it becomes.

The vertical columns are called groups. Group one, for example, on the left side of the table, contains a number of elements, which contain only one valence electron in their outer shell. This tends to make these elements unstable. On the right hand side of the table are the noble gases that are very stable because their outer shells are full of electrons.
The rows of the periodic table are also significant. They correspond to the shells of electrons, sometimes called quantum numbers, \( n = 1 \) through to \( n = 7 \). \( n = 1 \), the first shell is also the first row on the periodic table, and has only two elements, Hydrogen and helium. This is because only two electrons can be in the first shell. \( n = 2 \), the second shell, can have eight electrons and there are eight elements in this row. \( n = 3 \) can have 8, \( n = 4 \) can have 18 and \( n = 5 \) can have 18 as well. That is the number of elements in each of those rows on the table. When you get to \( n = 6 \) and \( n = 7 \) the table gets too big to put on a page so for convenience sake the periodic table is split and a group of elements are listed below.

The periodic table is an important and useful tool. Once the main properties of each of the groups are known it is possible to predict the chemical properties of any of the elements within that group.

**IONIC and MOLECULAR COMPOUNDS**

How is it possible that only 92 elements are found in the natural world, but there are millions of different types of substances? The secret is that atoms combine into compounds, which provide the great variety of chemical structures that make up the different substances we find in the universe.

Compounds are made up of combinations of atoms. When atoms bump into each other, the electric charges of the nucleus and the electrons of one are felt by the other. This is the electromagnetic force that binds atoms together. The way they do that is by sharing or donating the electrons in their outer shells. There is a natural tendency for atoms to seek equilibrium and fill their shells with electrons and they do this by combining with other atoms. The more full the outer shell of the atom, the greater its stability.

An ionic compound is formed when an electron from one atom is lost to another and the two ions form an ionic bond. They are held together by their opposite electrical charges, but they remain as individual ions.
A molecular compound, on the other hand, forms when atoms share some of their electrons in a covalent bond. Oxygen, for example, has eight electrons. In order to become stable and have a complete outer shell, it needs another two electrons. Hydrogen has only one electron, but when two hydrogen atoms combine with an oxygen atom, the three atoms in the molecule will share electrons in order to fill their outer shells. Two atoms of hydrogen and one of oxygen is a molecule of water, H2O, one of the most common and stable substances on our planet.

In some instances, two atoms of the same element combine. Oxygen in the atmosphere exists as a molecule of two oxygen atoms, O2. Hydrogen is often found as a molecule of two hydrogen atoms, H2.

When atoms combine, the resulting molecules can take on a character much different from their constituent elements. Hydrogen is highly explosive and oxygen burns, but put together, they create water, which puts out fire.

One of the marvels of modern chemistry is that scientists have even been able to create new molecular structures such as plastic. Chemists have learned to manipulate the molecular structures of petroleum to create products with the exact characteristics they want.

Not only have chemists learned to analyze the properties of molecules, but they have also developed their own way to describe them. Every chemist knows that H2 means that the molecule has two hydrogen atoms. The formula for butane - a highly flammable gas - is written C4H10. The molecule in this compound is made up of four carbon atoms and 10 hydrogen atoms. These types of formulas are an international shorthand that can be understood by everyone once they know the symbols for the elements.

**COMMON PHASES OF MATTER**
Matter cannot be created or destroyed. But matter can change its form. Water, for example, can be ice - a solid, a liquid, or it can evaporate and become a gas, but regardless of its form, the chemical structure of water never changes. It remains H2O.
Temperature and pressure influences the behavior of almost all elements and substances. Water freezes at zero degrees Celsius (32 Fahrenheit) and becomes a gas at 100 degrees Celsius (220 Fahrenheit). When a substance is a solid the atoms are compact, when it is in the form of a gas the atoms are much looser and when the substance is liquid the atoms behave in a manner somewhere between the two extremes.

In the last one hundred years science has gained a new understanding of matter. There is still much to be learned and intense research is going ahead in several important areas such as particle physics and the molecular structure of compounds. All of this research is deepening our understanding of matter and the sub-atomic world.
Pre-Test

Directions: This will help you discover what you know about the subject of matter before you begin this lesson. Answer the following true or false.

1. Matter and energy make up the physical universe. T_____ F______.

2. Electrons of atoms spin around the nucleus made up of protons and neutrons. T_____ F______.

3. Atoms are about the size of a drop of water. T_____ F______.

4. The force that binds atoms together is electricity. T_____ F______.

5. No particle is smaller than an atom. T_____ F______.

6. An atom with a unique number of protons is called an element. T_____ F______.

7. There are 92 elements found naturally in the universe. T_____ F______.

8. Atoms and molecules are the same thing. T_____ F______.

9. Almost all elements and substances can exist as a solid, a liquid, or a gas. T_____ F______.

10. Matter can be destroyed. T_____ F______.
# Elements of Physics: Matter: Atoms and Molecules

## Vocabulary Definitions

The following words and terms used in the program may be unfamiliar to you. Try to listen for these terms while viewing the program, pay close attention so you can later include them in your scientific descriptions, observations, and creative writing assignment activities.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>atom</td>
<td>The fundamental unit of matter found in the universe made up of a nucleus of protons and neutrons and orbiting electrons.</td>
</tr>
<tr>
<td>atomic number</td>
<td>The number of an element determined by the number of protons in its nucleus.</td>
</tr>
<tr>
<td>atomic weight</td>
<td>The weight of the element. Chemists usually use the term atomic weight while physicists use the term atomic mass. Except when matter is weightless, atom weight and atom mass are the same.</td>
</tr>
<tr>
<td>bosons</td>
<td>Sub-atomic particles of matter and energy. Photons that transmit light are bosons.</td>
</tr>
<tr>
<td>chemical formula</td>
<td>A shorthand description of the molecular make up of a compound.</td>
</tr>
<tr>
<td>covalent bonds</td>
<td>When two or more atoms combine by sharing some of their outer electrons.</td>
</tr>
<tr>
<td>electron</td>
<td>Negatively charged particles that orbit the nucleus of atoms.</td>
</tr>
<tr>
<td>element</td>
<td>An atom with a unique number of protons</td>
</tr>
<tr>
<td>energy</td>
<td>In physics, work, or the capacity to do work</td>
</tr>
<tr>
<td>hydrogen</td>
<td>An element with the atomic number of one and symbol of H. Hydrogen is the most common element in the universe.</td>
</tr>
<tr>
<td>ion</td>
<td>An atom with more or fewer electrons than protons</td>
</tr>
<tr>
<td>isotopes</td>
<td>Atoms that have more or less neutrons than protons</td>
</tr>
<tr>
<td>leptons</td>
<td>Sub-atomic particles outside the nucleus of atoms. Electrons are leptons.</td>
</tr>
<tr>
<td>matter</td>
<td>The material that makes up objects. Matter cannot be created or destroyed.</td>
</tr>
<tr>
<td>mass</td>
<td>The total quantity of an object's matter.</td>
</tr>
<tr>
<td>molecules</td>
<td>The compounds made up of two or more atoms.</td>
</tr>
<tr>
<td>neutron</td>
<td>The part of the nucleus of atoms that have no electrical charge.</td>
</tr>
<tr>
<td>noble gases</td>
<td>Gases whose outer shells are full, making them extremely stable.</td>
</tr>
<tr>
<td>nucleus</td>
<td>The center of an atom.</td>
</tr>
<tr>
<td>orbitals</td>
<td>The shapes of the orbits of electrons.</td>
</tr>
<tr>
<td>periodic table</td>
<td>The arrangements of elements according to their atomic number and group.</td>
</tr>
<tr>
<td>planetary model</td>
<td>The theory that electrons circle the nucleus of atoms like orbiting planets.</td>
</tr>
<tr>
<td>proton</td>
<td>Positively charged part of the nucleus of atoms.</td>
</tr>
<tr>
<td>quarks</td>
<td>The sub-atomic particles of matter. There are six different types of quarks but only two occur in the nucleus of atoms.</td>
</tr>
<tr>
<td>shells</td>
<td>Electrons orbit the nucleus of atoms in irregular patterns called shells. This is often called the quantum number.</td>
</tr>
<tr>
<td>transuranium elements</td>
<td>There are 92 elements found naturally in the universe. Several elements, with atomic numbers greater than 92, have been created under laboratory conditions. They are called transuranium elements.</td>
</tr>
<tr>
<td>uncertainty principle</td>
<td>The theory that it is impossible to know precisely the location of electrons.</td>
</tr>
</tbody>
</table>
Use the Right Word

Directions: Find the right word from the physics vocabulary list that completes the following sentences.

1. Physicists say that the universe is made up of ____________ and energy.

2. ____________ spin around the nucleus of atoms made up of protons and neutrons.

3. Protons have a ____________ electrical charge.

4. Protons and neutrons are made up of smaller particles called ____________.

5. Electrons circle the nucleus of atoms in complicated patterns called ____________.

6. Every ____________ has a unique number of protons.

7. The electrons in the outer shell of atoms are called ____________ electrons.

8. When an atom has more or fewer electrons than protons it is called an ____________.

9. The ____________ is a type of map that helps understand the elements and their relationships.

10. Molecular structures are called ____________.
Word Match

Directions: Connect the word with the proper definition.

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>atom</td>
<td>vaporous form of matter</td>
</tr>
<tr>
<td>electron</td>
<td>an arrangement of elements</td>
</tr>
<tr>
<td>elements</td>
<td>positively charged unit in the nucleus of an atom</td>
</tr>
<tr>
<td>gases</td>
<td>different types of atoms</td>
</tr>
<tr>
<td>matter</td>
<td>compounds of two or more atoms</td>
</tr>
<tr>
<td>molecules</td>
<td>fundamental unit of all matter</td>
</tr>
<tr>
<td>particles</td>
<td>particles that make up protons and neutrons</td>
</tr>
<tr>
<td>periodic table</td>
<td>sub-atomic structures</td>
</tr>
<tr>
<td>proton</td>
<td>physical substances or material</td>
</tr>
<tr>
<td>quark</td>
<td>negatively charged particle</td>
</tr>
</tbody>
</table>
Elements of Physics
Matter: Atoms and Molecules

Connected/Not Connected

Directions: Place the following words in the proper sentences.

atoms  hydrogen  negative  planets
electricity  ions  neutrons  positive
electrons  isotopes  nucleus  protons
elements  leptons  periodic table  quarks
gases  liquids  planetary model  uranium

1. ________ and ________ are connected because they are both in the nucleus of atoms.
2. ________ are NOT connected to the ________ of atoms because they orbit around this central core.
3. ________ and ________ are connected because they are both sub-atomic particles.
4. ________ are NOT connected to ________ because one is the basic form of matter and the other is a form of energy.
5. ________ and ________ are connected because both are atoms that are slightly different from a neutral atom.
6. The ________ of atoms is NOT like the orbits of ________ because the orbits of atoms cannot be predicted with certainty.
7. The ________ and ________ are connected because one is an arrangement of the other according to the number of protons in the nucleus of the atom.
8. A ________ charge is NOT connected to a ________ charge because they have opposite electrical forces.
9. ________ and ________ are connected because elements and substances can exist in these forms of matter.
10. ________ is NOT connected to ________ because one is the simplest and most common atom found naturally in the universe and the other is the most complex atom found naturally in the universe.
ELEMENTS OF PHYSICS
MATTER: ATOMS AND MOLECULES

Crossword Puzzle

Across
4. molecular structures
5. H2O
7. force that binds atoms together
8. combinations of atoms
10. an atom with more or fewer electrons than protons
12. an atom with more or fewer neutrons than protons
13. particles that orbit the nucleus
14. the _______ table orgaizes elements
15. made from petroleum

Down
1. the center of the atom
2. particles that make up protons and neutrons
3. positively charged part of the atom
6. element with atomic number one
9. an electron
11. an atom with a unique number of protons
Creative Writing Story Ideas

1. Through the magic of miniaturization you are shrunk down to the size of a quark and carried out of the laboratory on a gust of wind. What do you find in this strange sub-atomic world?

2. A group of scientists have discovered a form of anti-matter that counteracts the force of gravity. As a special experiment they place the anti-matter in the shoes of 10 high school students. What happens?

3. The Nobel Prize will be awarded to the team of scientists who can explain what quarks look like. Two teams of outstanding researchers are competing for the prize, but a third, led by a renegade particle physicist, is trying to steal their secrets so he can win the prize.

4. A spaceship from Earth has landed on a strange planet orbiting a distant star in a remote galaxy. The explorers are delighted to find that there is life on this planet but it is like nothing they have experienced before. Maybe these strange creatures are made of some form of matter that is unknown in other parts of the universe. Then, unexpectedly, disaster strikes.
ELEMENTS OF PHYSICS
MATTER: ATOMS AND MOLECULES

Video Quiz

Directions: Answer the following true or false, or fill in the blank with the correct word to make it true.

1. Matter and energy make up the physical universe. True_______ False _______.

2. The basic building blocks of all matter are called __________.

3. Each atom is made up of electrons that spin around a nucleus made up of protons and neutrons. True_______ False _______.

4. Electrical charges that are the same attract each other. True_______ False _______.

5. Protons and neutrons are made up of tiny particles called quarks. True_______ False _______.

6. The number of elements found naturally in the universe are __________.

7. The atomic number of an element is determined by the number of electrons in the nucleus of the atom. True_______ False _______.

8. An isotope has a different number of neutrons than protons in the nucleus of its atom. True_______ False _______.

9. Molecular structures are called __________.

10. Matter cannot be created or destroyed. True_______ False _______.

Name ____________________
ELEMENTS OF PHYSICS
MATTER: ATOMS AND MOLECULES

Post-Test

Vocabulary
Directions: Fill in the blank with the appropriate term from the list below.

atoms  electricity  elements  gases
hydrogen  ions  isotopes  liquids
negative  neutrons  nucleus  periodic table
planets  positive  protons  planetary model
atomic  isotopes  nucleus  sub-atomic
gases  liquids  periodic table  sub-atomic
electrons  leptons  periodic table  sub-atomic
ions  neutrons  periodic table  sub-atomic
neutrons  protons  periodic table  sub-atomic
planets  positive  protons  periodic table
positive  protons  periodic table  sub-atomic
protons  periodic table  sub-atomic
uranium  sub-atomic

1. __________ are composed of protons, neutrons, and electrons.
2. The force that binds atoms together is __________, a form of energy.
3. Quarks are __________ particles.
4. The atoms of some elements can have a different number of neutrons. These are called __________.

True or False
Directions: Fill in the blank with True or False. If the statement is false, change it to make the statement true. Rewrite the true statement in the space provided.

5. __________ An ion is a neutral atom.
6. __________ Every element has a letter symbol.
7. __________ The motion of electrons can be predicted precisely.
8. __________ Leptons are found in the nucleus of atoms.
9. __________ Matter can change its form but it cannot be destroyed.

Essay Section
Directions: Answer the following questions in complete sentences. Use the back of this page or a separate sheet of paper if you need more space to complete your answer.

10. Is it accurate to describe the physical universe as composed of only matter and energy?

11. Briefly explain why the number of electrons circling the nucleus determines the physical and chemical properties of the atom.

12. How is it possible that only 92 elements are found in the natural world but there are millions of different types of substances?