

All About Elements: Helium

Ward's All About Elements Series

Building Real-World Connections to the Building Blocks of Chemistry

PERIODIC TABLE OF THE ELEMENTS

KEY
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 Atomic Number
 Atomic Weight

A chemical element is the simplest form of matter that scientists can work with directly. All of the more complex substances are composed of elements in various combinations. But have you ever inquired about the properties of each of those individual chemical building blocks? Our universe is composed of trillions of substances that are all differing compositions of a finite number of elements. In this email series, we will delve deeper into each of the elements in order to gain more insight into their properties and uses and the substances they are used to create.

In our *All About Elements* series, we've brought together the most fascinating facts and figures about your favorite elements so students can explore their properties and uses in the real world and you can create chemistry connections in your classroom and beyond.

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Fun Facts About...Helium

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- Helium is the second most abundant element after hydrogen in the universe and solar system. Approximately 11.3% of all atoms in the universe are helium atoms. When this number is added to the 88.6% of the atoms in the universe that are hydrogen, scientists conclude that at least 99.9% of all atoms in the universe are either hydrogen or helium atoms.
- Helium was discovered in the Sun's atmosphere before it was found on Earth.
- Helium exists in Earth's atmosphere only because it is constantly resupplied by the decay of radioactive elements on earth, such as uranium and thorium.
- The helium we used today is harvested through the same process that natural gas is harvested.
- The "lighter than air" properties of helium make it perfect for inflating party balloons, weather balloons, blimps and even the massive balloons seen each year in the Macy Thanksgiving Day Parade. In fact, to fill 15 of the balloons that are seen walking the streets of New York, organizers had to use approximately 300,000 cubic feet of helium. This is the equivalent volume of 2.2 million gallons of milk, or hydrogen combining with oxygen. The reaction is equivalent to burning hydrogen; however it is much slower and more controlled and produces electrical energy to power the vehicle instead of heat.

All About Helium:

Helium is the second element on the Periodic Table of Elements. It is the first noble gas that we encounter on our trip around the table, and that means that it is also an inert gas. Inert means that the element is not very active, and will not combine with other elements or compounds. As a matter of fact, there have been no compounds of helium ever made! The reason that helium and all other noble gases are inert is because they have completely filled electron shells. They do not need any other electrons to "feel complete." But do not assume that helium is boring just because it does not form compounds with other elements. Helium may be colorless, odorless and tasteless, but it shows up in exciting process such as semiconductors, birthday balloons, welding and the Large Hadron Collider just to name a few.



Large Hadron Collider

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Properties of Helium

In addition to being the second element on the Periodic Table, it is also the second most abundant element in the universe. Only Hydrogen is more abundant! These two elements were copiously formed during the creation of the universe. In the early stages of the universe, helium and hydrogen nuclei were actually formed. No atoms were formed until about 300,000 years after the Big Bang took place, when the universe became cold enough to form electrons that would combine with existing nuclei to form atoms. The helium nuclei that were originally created still exist today in two different forms. The first is helium-4. Helium-4 has two protons and two neutrons. The second is helium-3, which also has 2 protons but only has 1 neutron. Helium-4 and helium-3 are both being made each day inside every star in the sky due to nuclear fusion reactions between hydrogen nuclei. It is no surprise then that about 1 out of every 10 atoms or nuclei in the universe is that of helium. It is estimated that about 11.3% of the atoms in the universe and solar system are helium atoms. When this number is added to the approximate 88.6% of the hydrogen atoms in the universe, scientists estimate that at least 99.9% of all of the atoms in the universe are either hydrogen or helium atoms!

This 11.3% abundance is in drastic contrast however to the abundance of helium atoms on Earth. Helium is the 6th most abundant gas in Earth's atmosphere after nitrogen, oxygen, argon, carbon dioxide, and neon. Helium only makes up 0.0005% of the air that we breathe each and every day. Most of the helium atoms that were present in the Earth's atmosphere at the beginning were able to escape Earth's gravitation pull very early due to their light mass and resulting speed. This is not the case for all planets in our solar system. The atmosphere of Jupiter is very dense and contains about 24% helium by mass, mainly because of the cold temperatures of Jupiter and the much stronger gravitation pull. Molecules of helium have a much harder time gaining enough speed to break free from the gravitation pull of the gas giant

Discovery and History

Now you may be asking that if helium has the ability to leave our atmosphere, how we still have a constant 0.0005% left. Well, the answer lies in the formation of helium deep within the Earth's crust. Helium only exists in Earth's atmosphere because it is constantly resupplied by the decay of radioactive elements such as uranium and thorium. This radioactive decay process was not understood however for many years after the original discovery of the element Helium. Let's take a walk through history and discover however helium was discovered and how constant radioactive decay allows us to use it for our birthday party balloons.



Photo of Jupiter

The Sun was actually the first place that helium was discovered. French astronomer Pierre Janssen was in India in August 1868 to witness a total solar eclipse. He used a spectroscope in order to view the wavelengths of light coming from the sun. A spectroscope is a powerful instrument used to study chemical elements, and break the wavelengths of light that we see with the naked eye as one constant color, into its basic parts. These basic parts consist of a series of colored lines. These lines are called the element's spectrum, and each element has its own distinct spectrum. Spectroscopes allow scientists to see an elements spectrum, even if they cannot see the element itself. When Janssen was using the spectroscope to better observe the full eclipse of the sun, he identified some spectral lines that could not be traced to any known element. He therefore concluded that there must be an element of the Sun that had never been seen on earth. At about the same time an English physicist named Joseph Norman Lockyer noticed a similar bright line, with a wavelength of 587.49 nanometers, in the spectrum of sunlight and also concluded that no known element was responsible for it. Lockyer suggested that this new mystery element be called helium, after the "Helios" the Greek word for sun.

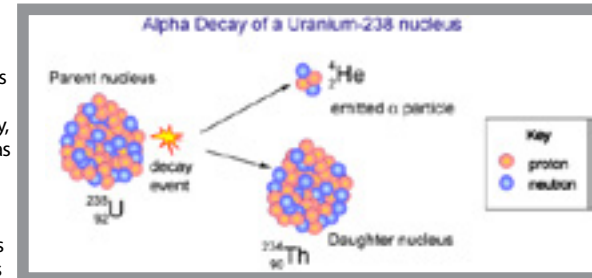


Where in the World is Helium?

For nearly 30 years, chemists and physicists were baffled by this mystery element that was identified on the Sun but could not be found on Earth. It wasn't until 1895 when Scottish chemist William Ramsay found helium when he isolated the gas that was formed when mixing uranium ore with acids. Although Ramsay was searching for argon, he analyzed the gas sample produced and realized that the spectrum matched that of Lockyer's helium. Credit for the earthly discovery of helium is sometimes given to two other scientists also. Swedish chemists Per Theodor Cleve and Nils Abraham Langlet also discovered helium at about the same time in a mineral called cleveite. While Ramsey had identified that helium was present in the uranium ore, he was not clear on why it was present there. It was not until 1907 that this answer would become clear.

Formation of Earthly Helium

English physicist Ernest Rutherford was one of the great scientific figures of the 20th century. He made a number of important discoveries about the structure of atoms and about radioactivity, one of which led to the understanding of why helium was found in uranium ore by Ramsay in 1895. Rutherford discovered that one form of radiation given off by radioactive materials is an alpha particle. In 1907 he discovered that alpha particles are simple helium atoms without their electrons, and as uranium atoms broke apart during radioactive decay, they gave off alpha particles (helium atoms). This is why helium was first found on Earth in connection with uranium ore.



Around the same time, scientists began to suspect that helium was lurking in natural gas. According to the American Chemical Society, in 1903 a new natural gas well was opened in Dexter Kansas. During the town celebration, the mayor attempted to ignite the escaping gases, only to find that the flames continuously went out. While this was very disappointing for the attending townspeople, Kansas State geologist Erasmus Haworth became curious. He studied the gas from the well only to find that 12% was comprised of inert gases. Over the next two years he discovered that helium was one of the inert gases present in the natural gas, due to the radioactive decay or materials such as uranium and thorium. Together these elements produce about 3000 metric tons of helium a year that escapes from the Earth's crust with the natural gas. Helium is able to be isolated from natural gas reservoirs deep beneath the Earth's surface. As the helium comes to the surface with the natural gas, the temperature of the mixture is lowered, and the natural gas liquefies and is funneled away, the gaseous helium is left behind. As a result of the discovery that helium is present in many natural gas deposits, the price of helium plummeted and the United States built a facility to stockpile the gas mainly from natural gas deposits in Texas, Oklahoma and Kansas. Approximately 80% of the world helium is produced in the United States and for many years, the US government operated the Federal Helium Program. This program was responsible for collecting and storing helium for government use. The main customers for this helium were the Department of Defense, the National Aeronautics and Space Administration and the Department of Energy. In 1996 this program ended and the Bureau of Mines has now begun to sell of the federal reserves of helium.



Crude helium enrichment unit

Uses of Helium Today

Helium has a very low temperature and boiling point, and therefore remains in its gaseous form until it is cooled to extremely cold temperatures. It is also the lightest of all the Group 18 noble gases and is "lighter than air." These two properties combined with helium's unreactivity make it the perfect element for use in a variety of different applications such as inflating balloons and blimps, shielding during welding operations, pressurizing fuel tanks in liquid fueled rockets, cooling superconductive magnets, and for making our voices "squeaky!"



Magnetic Resonance Imaging (MRI) Machine

It is often the joke at birthday parties to cut open a helium balloon and inhale the gas. This causes the person's voice to sound squeaky. Because the speed of sound is much higher in helium than in natural air, it has the same effect as shrinking the cavities inside the mouth and nose, and therefore higher frequencies resonant causing the sound to appear higher even though the voice box produces exactly the same range of frequencies. While this is a fun trick to play every so often, breathing in lungs full of helium, or any other gas, prevents oxygen from reaching the body's tissue and can cause suffocation, and death.

Today, helium is frequently found in laboratories that require extra-cold temperatures for experiments, because it can be chilled to temperatures near absolute zero. In fact, most of the helium that is used in the United States is used in industry and to cool the magnets in magnetic resonance imaging (MRI) machines. Liquid helium also cools the magnets of the Large Hadron Collider, the world's largest particle accelerator, down to -456.34 F (-271.3C). The National Aeronautics and Space Association, or NASA, uses liquid helium to keep rocket fuel cool prior to launch. Also many components of airplanes and spaceships are exposed to thermal cycling during their manufacturing process in order to harden the components and make them durable for the demands that will be put on them. This cold phase of this repeated cooling and heating process is normally achieved using liquid helium as well.



Macy's Thanksgiving Day Parade Snoopy Balloon

Have you ever wondered how much helium it takes to inflate a birthday party balloon? How about something larger such as a blimp? Well, according to parade organizers, it takes approximately 300,000 cubic feet of helium to float the 15 character balloons in the Macy's Thanksgiving Day Parade! That is the equivalent volume of 2.2 million gallons of milk. While helium does not have the lifting power that hydrogen has, hydrogen is a flammable gas, while helium is not, and therefore it is the gas of choice for our party balloons, weather balloons and blimps.

Helium is also used during welding operations due to its inactivity. Welding is a process by which two metals are heated to high temperatures in order to join them to each other. Welding however does not work well in "normal" air due to the presence of oxygen. At high temperatures, the metals are able to react with the oxygen in the air to form metal oxides. If this occurs, they are less likely to form a solid bond and therefore welders often work in a container of helium. The metals do not react with the helium and therefore a stronger bond is formed.



Welding under inert Helium gas

Teach All About Helium with these Hands-on Materials:

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Radioactive Decay Cubes Lab Activity

How Long Will Radioactive Material Last?

Radioisotopes have been found to be useful in the fields of geology, medical diagnosis and treatment, metallurgy, agriculture, and scientific research. In this lab activity, students will use the framework concepts of Matter and Its Interactions (PS1) to explore the concepts of radioactive decay and half-life. They will determine the half-life of two different "elements," as well as graphically represent the observed decay. Students will also be able to investigate what happens when a parent nuclei decays into daughter nuclei over time.

Item Number: 366854



Electrodeless Spectrum Tube Power Supply

Safe Spectrum Power Supply with Encased Spectrum Tubes

This innovative device far surpasses the safety, capability, and convenience of any other spectrum power supply available for education. Most current power supplies dangerously expose students to 5,000V. This device's new, advanced design and features eliminate student's contact to the voltage source. This safety feature allows you to focus more attention on your students' learning experience instead of worrying about their safety.

Item Number: 161505

Spectrum Discharge Tubes, Deuterium

Dramatic Demonstration of Different Wavelengths of Light

Ideal for wavelength determination and introducing students to the spectra of better known gases, these glass tubes are 10" long, and the capillary portion is about 4" long. The spectrum tube assemblies can be used in a variety of spectroscopic applications. When they are observed through a spectroscope the emission lines corresponding to the energy transition levels of the gaseous atoms or molecules will appear as distinct components. For use with Spectrum Tube Power Supply.

Item Number: 160576



Spectrum Tube Power Supply

Built With Safety and Ease of Use In Mind

Connecting sockets are fully shielded to prevent electric shock. The bottom socket is spring loaded so tubes can be changed easily. Output 5,000 V, 10 mA, 115 V. The cord is 8'. Overall dimensions: 14 1/2" x 4 1/2" x 3".

Item Number: 160569



Show Me Science: The Sun - Powerhouse of the Solar System

The Sun releases energy that powers the entire Solar System. Charged particles from the core's chemical reactions create a stream of plasma that escapes the Sun's atmosphere. That stream is called the solar wind and contains the entire spectrum of electromagnetic radiation. The Sun creates an enormous magnetic field that regularly twists, triggering mass ejections or flares that turn the solar wind into a storm. The Sun is only one of more than 200 billion stars in the Milky Way. Students will see the enormous span of the Universe, some of our neighboring stars and an excellent description of the life of a star.

Item Number: 470123-136



Show Me Science: Jupiter - The King Planet

Beyond the Asteroid Belt lies Jupiter, the largest planet in the Solar System. It is a ball of gas with no solid surface. Regal Jupiter is orbited by more than 60 moons of which four are large enough to be small planets.

Item Number: 470123-194





Student Spectrometer

This spectrometer may be economically priced, but it's still capable of performing many different types of experiments involving spectras, angle of prisms, refractive indexes and more.

This Student Spectrometer consists of a heavy base with a 170mm diameter circle, divided into 360 degrees, which rotates independently and has a locking screw. Other fine features of the spectrometer include: a fixed collimator with an adjustable axis; an objective lens with a quality, lockable focusing system, a variable aperture slit and a Ramsden eyepiece with cross-wires; a moveable telescope featuring a set screw, a fine motion screw and an adjustable axis, and a telescope pillar with a vernier scale for accurate measurements; a prism table with 3 leveling screws and engraved lines and a clamp for prism placement in experiments; and a grating holder

Item Number: 160416

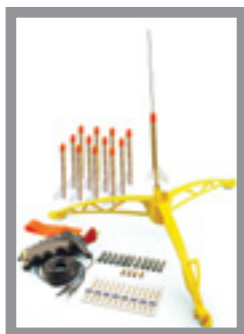


Project STAR Spectrometer

View Spectra with an Accuracy of ± 1 Nanometer

Examine the spectra of the Sun and stars, and those produced by minerals in flame tests. It features a high-quality grating and stepped slit for a clear, precise, spectrum. The sturdy plastic construction is labeled with both electron volts and nanometers, as well as a chart of common spectral lines. An instruction manual is included. Size: 12"L x 8 1/2"W.

Item Number: 255005

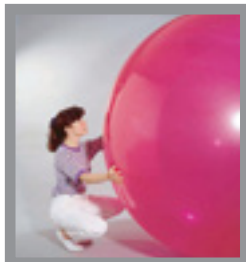


Beingo Micro Rockets

Micro Rockets Are Perfect for Use in Groups

Explore model rocketry using affordable micro size rockets that enhance your STEM curriculum. They require a small launch site of only 50 feet in diameter and their limited altitude equals an easy tumble recovery. Kit includes rockets, motors, igniters, launch pad and controller—everything necessary for a group of twelve students.

Item Number: 160113



Meteorological Balloon

2 M Diameter

Item Number: 231275

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