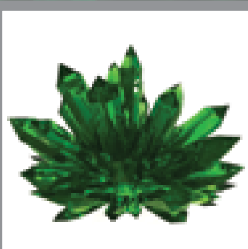
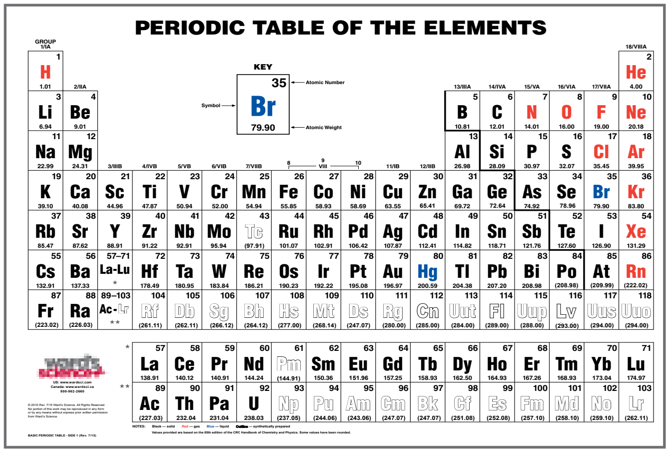


All About Elements:

Beryllium

Ward's All About Elements Series

Building Real-World Connections to the Building Blocks of Chemistry



The periodic table of elements is an essential part of any chemistry classroom or science lab, but have you ever stopped to wonder about all of the amazing ways each element is used to create the world around us? Each of the trillions of substances in our universe can be tied back to just these 118 simple, yet powerful elements.

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.

Look for a new featured element each month, plus limited-time savings on select hands-on materials to incorporate these element in your lessons.

Follow us on: **OR** **Sign up to receive Ward's Science emails** at **wardsci.com** and get a new element in your inbox each month.

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Fun Facts About... Beryllium

4
Be
9.012

1. Prior to being named beryllium, this element was known as glucinium, which originated from the Greek word glykys, meaning sweet. It was so named due to it characteristic sweet taste.

2. Emerald, morganite and aquamarine are precious forms of beryl.

3. Beryllium is resistant to concentrated nitric acid.

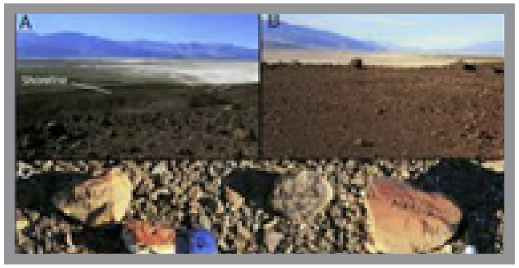
4. Where beryllium is rather transparent to x-rays, this element and its compounds are highly reflective to infrared light.

5. Between 1998 and 2000 beryllium-aluminum-alloy pistons were used in the McLaren Formula One racecar used by Mercedes-Benz.

All About Beryllium:

Beryllium is the fourth element on the Periodic Table of Elements, found in group 2 (2A), with atomic number of 4, and symbol Be. Beryllium contains two valence electrons, with a configuration of 1s22s2, making it an alkaline earth metal. Interestingly, beryllium is unlike other alkaline earth metals in that it does not form ions. The result of this is all beryllium compounds are covalent compounds rather than ionic compounds. Beryllium is denser than water, with a density of 1.85 g/cm^3. In its pure elemental form it is a shiny-gray metal that is relatively brittle at room temperature. It is estimated that the crustal abundance of beryllium on Earth is only 2.8 mg/kg, mainly concentrated in soils, however beryllium is found in over 100 mineral species, including bertrandite, beryl, chrysoberyl, and phenacite. Beryl and bertrandite are the most important commercial sources of the element and its compound today. In fact, the name of beryllium originated from beryllos, which is the Greek name for the mineral beryl. Prior to being named beryllium however, this element was known as glucinium, which originated from the Greek word glykys, meaning sweet. It was so named due to its characteristic sweet taste. Early chemists actually tasted the unknown element in order to determine its taste. However, the chemists who discovered this unique property of beryllium also found that it is in fact **highly toxic and should therefore NEVER be tasted**!

Properties of Beryllium



A) View NW across Death Valley showing the location of the shoreline from where 10Be TCN samples were collected. B) Surface of the shoreline that was sampled. C) Views of several of the sampled cobbles on surface of the shoreline. (L.A. Owen et al. / Geomorphology 125 (2011) 541–557)

Beryllium has both stable and unstable isotopes, which are all created in stars. Radioisotopes of beryllium are very short lived however, some with half lives as short at 7 x 10^{-17} seconds (8Be) and 2.7 x 10^{-21} s (13Be). The most common stable isotope of beryllium was created in the interstellar medium when cosmic rays induced fission in heavier elements found specifically in interstellar gas and dusts. There is only one stable isotope of beryllium, 9Be, and therefore it is a monoisotopic element. The isotope 10Be is a radioactive isotope of beryllium that accumulates in the earth's soil, where it enjoys a long half life of 1.36 million years. Due to this extremely long half life, 10Be is used by geologists and soil scientists to examine soil erosion, soil formation, and the development of lateritic soils. It also has scientific significance in ice core dating.

Discovery and History

Emerald, morganite and aquamarine are precious forms of beryl. Ancient civilizations utilized emeralds and beryl, however it was not until 1798 that geologist Abbé Hauy believed that they contained the same mineral. Hauy then asked his French chemist friend Louis-Nicholas Vauquelin to analyze the two samples. Vauquelin realized that the two samples did indeed contain an unknown element and set off to determine what the unknown element was. Later the same year, Vauquelin made his discovery public at the French Academy, and is credited for the discovery of what is now known as the element beryllium. It took another 30 years however until two chemists, Friedrich Wöhler of Germany and A. Bussy of France, were able to isolate the pure element. These two chemists independently produced beryllium by means of reduction chemistry. They took beryllium chloride (BeCl2) and reduced it with potassium in a platinum crucible. It has also been discovered that the green color in gem-quality forms of beryl, such as emerald, comes in fact from trace amounts of chromium present.

Where in the World is Beryllium?

Location & Production

In the Earth's crust, the concentration of beryllium is between 2 and 6 ppm. For commercial production of beryllium metal, beryllium alloys and beryllium oxide, the specific minerals that are of utmost importance are beryl ($Al_2Be_3Si_6O_{18}$) and bertrandite ($Be_4Si_2O_7(OH)_2$). These minerals are mainly found in China, Kazakhstan and the United States. The Spor Mountain area in Utah has particularly large reserves of bertrandite that are currently being mined. Reserves of beryl are so low that it is no longer cost effective to hand-sort the stone from pegmatite deposits in order to harvest the beryllium. It is estimated by the United States Geological Survey that Utah has total reserves of bertrandite of 15,000 tons. Worldwide reserves of beryllium (in the form of bertrandite) have been estimated by the USGS to be 80,000 tons, with about 65% of this residing in the US.

Once the bertrandite is mined, it is wet milled, leached with sulfuric acid, and then extracted from the acid leachate with di(2-diethylhexyl) phosphate in kerosene at elevated temperatures. The beryllium is then treated with aqueous ammonium carbonate to form an aqueous ammonium beryllium carbonate complex, which is then heated to precipitate beryllium carbonate. Continued heating liberates carbon dioxide and beryllium hydroxide ($Be(OH)_2$). Beryllium hydroxide is then recovered by filtration and is the main compound used in the production of beryllium metal, beryllium alloys and beryllium oxide.

In order to produce pure beryllium metal, the beryllium hydroxide is first converted into beryllium fluoride or beryllium chloride. To form beryllium fluoride, beryllium hydroxide has aqueous ammonium hydrogen fluoride added to it to yield ammonium tetrafluoroberyllate. This precipitate is then heated to 1000°C which yields beryllium fluoride. Using heat again at 900°C with magnesium, results in finely divided beryllium and continued heating up to 1300°C results in the compact metal. Conversely, simply heating the beryllium hydroxide will result in the oxide form of beryllium, which can easily become beryllium chloride when combined with carbon and chlorine. Electrolysis is then performed in order to obtain the pure metal. Only a few hundred tons of metallic beryllium is produced each year.

The majority of the beryllium that is produced is actually used to produce "beryllium copper" alloy, which contains up to 3 percent beryllium by weight and is remarkably flexible, elastic, and hard wearing. Many products are made from this versatile alloy such as springs, and even tools. Mixing 2% beryllium with 98% copper produces a substance known as beryllium bronze that is used in gyroscopes and other sensitive devices, where wear resistance is a required property. Another alloy is made by mixing 2% beryllium with 98% nickel, which is used to make spot-welding electrodes, as well as springs and tools, much like beryllium copper alloy is. Other more complicated beryllium alloys are actually used to make products such as windshields, break disks and integral structural components used in the aerospace industry. Mixing beryllium with each of these metals increases their electrical and thermal conductivity and also makes their physical properties more favorable for specific applications. For example, beryllium copper is used to make tools that can be used in hazardous environments in which there are flammable gases or magnetic fields, because they produce no spark when struck and are non-magnetic.

How is Beryllium Being Used to Innovate?

In addition to being non-magnetic, Beryllium has other properties that make it an excellent metal and alloying material for use in a variety of different industries. Beryllium for instance is one of the lightest metals and has one of the highest melting points among these light metals. It also has a modulus of elasticity that is approximately one-third greater than steel, making it useful for building materials as well.

Another unique quality of beryllium is that it is resistant to concentrated nitric acid. Under normal temperature and conditions, beryllium has superior thermal conductivity and resists oxidation. Lastly, due to its high melting point, beryllium oxide is a useful material for nuclear and ceramic applications. In fact, in 1932 James Chadwick discovered the existence of the neutron by bombarding a sample of beryllium with alpha rays from the decay of radium. This is now one way in which laboratory neutrons are produced. (30 neutrons are produced for every million alpha particles) Some of the interesting applications using beryllium and its alloys can be found below.

Radiation Windows

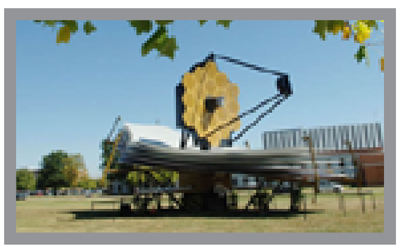
One of the oldest and best known applications of beryllium is in the production of radiation windows for x-ray tubes. Beryllium is specifically used due to its low atomic number and very low absorption of x-rays. It is also used to produce thin foils that are used in the radiation windows of x-ray detectors. This ultra-thin foil is also finding use in x-ray lithography for reproduction of micro-miniature integrated circuits.

Beryllium Copper Wrench

Beryllium x-ray diffusion bonded window assemblies

The low atomic number of beryllium makes it fairly transparent to energetic particles and therefore it has use in particle physics apparatuses. Beryllium is the material used for the beam pipe around the collision region of all four main detector experiments at the Large Hadron Collider, the Tevetron and the SLAC. Its low atomic number gives it a low density, allowing collision products to reach the surrounding detectors without interaction. It is also a very stiff material, which allows the necessary high vacuum to be produced within the pipe to minimize any interactions and berylliums thermal stability allows all of these properties to be present at very low temperatures (a few degrees above absolute zero). Lastly, it does not interfere with the complex multipole magnet that is used to steer and focus the particle beams because of its non-magnetic properties

The Large Hadron Collider is the world's largest and most powerful particle accelerator.



James Webb Space Telescope

Mirrors

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Smaller beryllium mirrors have been used for optical guidance systems and in fire-control systems such as on the German-made Leopard 1 and Leopard 2 main battle tanks.

Fluorescent Lights

During WWII there was a rising demand for beryllium-copper alloys and phosphorus for use in fluorescent lights. Early fluorescent lights emitted a greenish light because they utilized zinc orthosilicate with various concentrations of beryllium. In order to improve the color of the light, over time small amounts of magnesium tungstate were added to yield an acceptable white light. After it was discovered that beryllium was a toxic material and should not be handled without proper protection, fluorescent light composition changed to include halophosphate-based phosphors rather than beryllium-based phosphors.

Mechanical Products

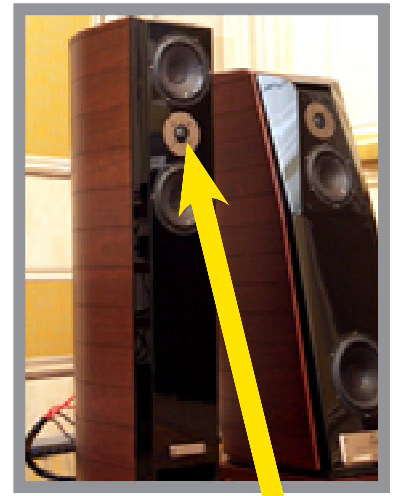
1998 Formula 1 McLaren MP4-13

We have discussed a number of physical properties of beryllium including its low molecular weight, stiffness and dimensional stability over wide temperature ranges that make it the perfect metal for many lightweight structural components used in the defense and aerospace industries. This lightweight metal and its alloys can be found used in high-speed aircraft, guided missiles, spacecraft, and satellites. Between 1998 and 2000 beryllium-aluminum-alloy pistons were even used in the McLaren Formula One racecar used by Mercedes-Benz! Beryllium and its alloys have also been used extensively in the production of precision instruments, such as inertia guidance systems, optical systems and gyroscopes, due to its high elastic stiffness. And were used in military aircraft breaking systems, however due to environmental conditions, this use has been discontinued today.

Beryllium-containing minerals are also used in cell phones, other portable devices and cameras, and have been present in parts of the analytical equipment used to test blood for HIV and other diseases.

Acoustics

High-end home and pro-audio systems, as well as large public address systems use beryllium as the high-frequency driver. This is mainly due to its high rigidity and low molecular weight. However, beryllium is much more expensive than other metals used for this purpose, such as titanium, and it is often hard to shape due to its extreme brittleness. For these reasons many speaker manufacturers have shied away from using beryllium for their tweeters.



Usher Audio debuted two new speakers with beryllium tweeters.

Health Concerns Related to Beryllium

Although there are many important applications of beryllium used throughout a variety of different industries, proper handling procedures must be followed when exposure to beryllium is possible. Beryllium has the ability to displace magnesium from enzymes within the human body and when this occurs, those enzymes malfunction cause health issues. Chronic berylliosis is one disease associated with exposure to beryllium dust or fumes either over short or long periods of time. This disease can take up to five years to develop and attacks the pulmonary system. The Occupational Safety and Health Administration (OSHA) has designated permissible exposure limits (PEL) for exposure in the workplace with time-weighted averages (TWA) of 0.002 mg/m^3 and a constant exposure limit of 0.005 mg/m^3 over 30 minutes. The National Institute for Occupational Safety and Health (NIOSH) has also set limits related to recommended exposure to beryllium. Therefore, the commercial use of beryllium requires the use of appropriate dust control equipment and industrial controls at all times because of the toxicity of inhaled beryllium-containing dusts that can cause this chronic and life threatening allergic disease. Beryllium is classified as a carcinogen by the International Agency for Research on cancer.

Teach All About Beryllium with these Hands-on Materials:

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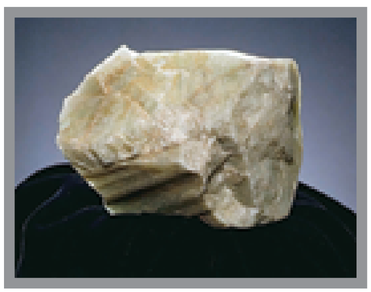
Beryl Crystal

Single and xls sections. China.

Item Number: 491033



Beryl, Student Specimens, Pack of 10

Bluish-green to white, massive, trimmed from large single crystals. This package of 10 student specimens are ideal for students to use for study and identification. Specimens range in size from 1" x 1" to 1" x 2".

Item Number: 461122

Gyroscope

Illustrate Gyroscopic Forces with a High-Quality Instrument

It may look like a toy (in fact, it was included in NASA's 1993 Toys in Space project), but this fascinating device demonstrates the ability of a wheel to spin in a fixed position in space, resisting any altering forces. The gyroscope features near-perfect balance, spinning on high-quality ball bearings for several minutes at a time. It includes a user's guide with suggested activities. Size: 3 ¼" dia. x 5" H. Available individually or in case of 24.

Item Number: 160611

⚠ **WARNING:** **CHOKING HAZARD—Small parts. Not for children under 3 yrs.**

Mirror and Lens Supports, Pack of 6

Item Number: 252009

Intelligent Plant Light

Internal Computer Regulates Daylight Cycle Automatically

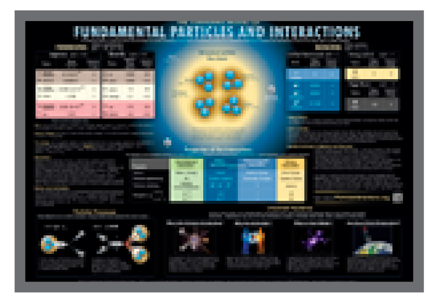
Grow plants in areas with little or no light. The Intelligent Plant Light is a table-top, telescoping fluorescent lamp that allows anyone to successfully grow a plant in areas with little or no light. All you do is set the season once, and the internal computer begins the daylight cycle turning the lamp on and off automatically, simulating nature's clock of summer, fall, winter, spring for optimum plant growth. The computer also monitors soil moisture content and indicates when water is needed. Versatile features include a 9W full spectrum lamp to duplicate the sun's rays, an adjustable stem to accomodate plants of varying heights at different stages of growth from 4" to 12", and a pebbled base to catch water.

Item Number: 205150

CPEP Fundamental Particles and Interactions Charts Poster, 30 x 21"

Fundamental Particles and Interactions brings current particle research onto one chart in three sizes. All new, with a completely new design and greatly updated content. Now includes the newly discovered Higgs boson, more about neutrinos and "Unsolved Mysteries" including dark matter, dark energy, antimatter, and extra dimensions. All the latest information on the subatomic world of quarks, electrons, neutrinos, gluons, antimatter, and the top quark, °.

Item Number: 470067-242



ward's science