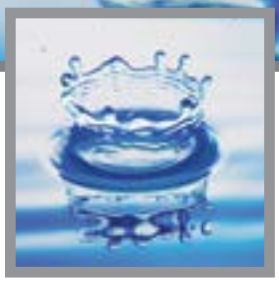


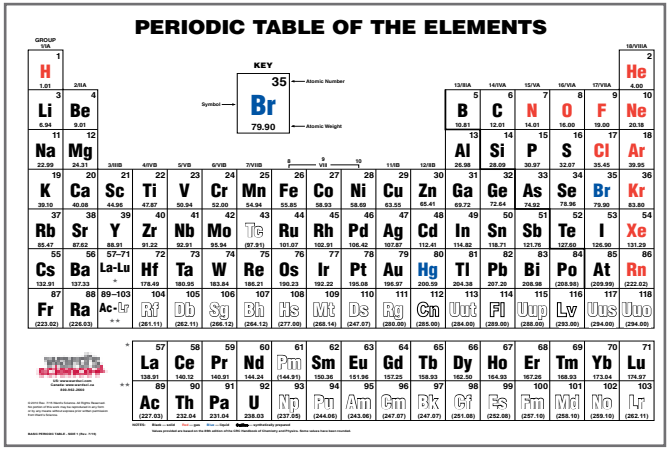
All About Elements:

Hydrogen

ward's science

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.

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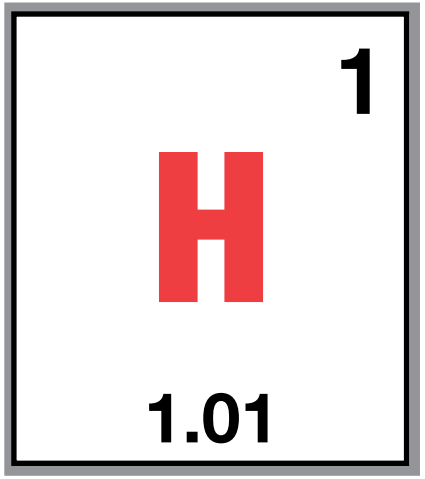
Fun Facts About... Hydrogen



1. Robert Boyle produced hydrogen gas as early as 1671 while he was experimenting with iron and acids.
2. Under the extreme pressures at the centers of giant gas planets such as Jupiter, hydrogen behaves as a metal.
3. More than 10% by mass of any ocean is hydrogen, even though the atomic mass is only 1 amu.
4. The double helix of DNA would not exist without the hydrogen bonds that hold the two strands together.
5. Hydrogen Fuel Cells facilitate a chemical reaction which is simply a reverse electrolysis reaction, 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 Hydrogen:

Hydrogen is the most abundant element, and comprises nearly 75% of all ordinary matter in the universe (by mass), and approximately 90% of all atoms in the universe.

Hydrogen gas is highly flammable. When compressed, it becomes a liquid (liquid hydro¬gen).

At normal temperature and pressure, hydrogen is in the form of H_2 – two hydrogen atoms bound together. Here on Earth, hydrogen in this form is very rare. Being lighter than air, it rises from the atmosphere. More commonly, hydrogen is found in combination with other elements. The most common example is when hydrogen (H_2) is combined with oxygen (O) to form water (H_2O). However countless critical processes for life require the use of hydrogen as well.

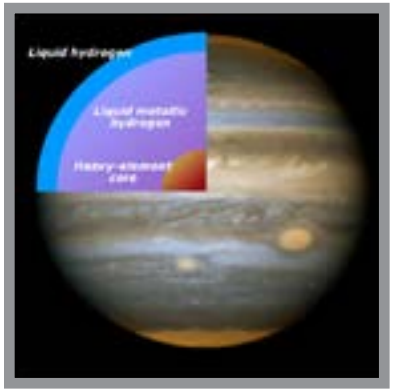
(Credit: © Yuriy Mazur / Fotolia)

Properties of Hydrogen

With an atomic number of 1 and atomic weight of 1.00794 Hydrogen is officially in Group 1 of the periodic table, but considering it is so drastically different than all other elements in Group 1, it is generally considered to be in a category all on its own.

There is a single electron that orbits the nucleus of a hydrogen atom, and therefore only has a half filled "s" orbital. Because of this nature, hydrogen is very quick to give up its one negative electron and become a positively charged H+ ion. On the flip side, due to the same half filled "s" orbital, a hydrogen atom will just as easily accept another electron to have a full "s" shell, and thereby becomes a negative hydrogen ion, H-.

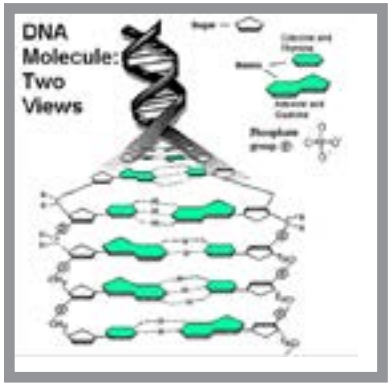
Hydrogen also can exist as a gas at room temperature (H_2, also called dihydrogen), which also distinguishes it from other Group 1 elements, as they are all metals. However, under the extreme pressures at the centers of giant gas planets such as Jupiter, hydrogen does behave as a metal!



(Compositional profile for Jupiter (Image courtesy NASA/STScI)

Discovery and History

Harry Cavendish has been credited with discovering Hydrogen in 1766, however scientists had been producing hydrogen for years before it was ever recognized as an element. Robert Boyle produced hydrogen gas as early as 1671 while he was experimenting with iron and acids. In 1792, French chemist Antoine Lavoisier discovered the reason hydrogen produced water when it burned (which had stumped Cavendish) and officially named the element hydrogen, from the Greek for "water generator".



(Photo credit: Access Excellence @ the National Health Museum)

Where in the World is Hydrogen?

Most of the hydrogen on Earth is tied up with an oxygen molecule, in water molecules, H_2O. Therefore, more than 10% by mass of any ocean is hydrogen, even though the atomic mass is only 1 amu! Water is used as a solvent for many applications, because of its ability to easily dissociated in OH- and H+ atoms, which can then hold on to other ions by an electrostatic attraction called Hydrogen Bonding. A great concentration of H+ ions in a solution will lead to that solution being considered acidic (the pH is measured greater than 7).

In addition to water, all living things contain hydrogen atoms in some form or another. This is because every organic molecule contains at least one hydrogen atom, and these molecules include proteins, carbohydrates and fats. The hydrogen atoms give large organic structures stability due again to the electrostatic interactions. In fact, the double helix of DNA would not exist without the hydrogen bonds that hold the two strands together!

How is Hydrogen Being Used To Innovate?

Hydrogen has a great deal of uses. It is used in the processing of fossil fuels, the production of ammonia, food processing, refining metals, and as rocket fuel, just to list a few examples. As it is not found naturally in elemental gas form, hydrogen must be synthesized (made) when needed. The most common method of producing hydrogen gas is steam reforming. In this process, hydrogen is separated from methane (CH_4) and captured. Methane is a fossil fuel and the process of steam reforming leads to the formation of greenhouse gases. Another method is the electrolysis of water.

Fuel Cells

With concern for the environment in mind, scientists have been experimenting with using hydrogen as a fuel source. Current fossil fuels such as oil, coal and natural gas, consist of mainly hydrocarbons, which do contain hydrogen, however when they burn, oxygen atoms combine with the hydrocarbons, and produce carbon dioxide (CO_2) and water (H_2O). There are many environmental pushes to cut down on the amount of carbon dioxide that we are emitting into the atmosphere. This, coupled with the need to limit the use of fossil fuels due to our diminishing reserves, has pushed scientists to look for alternatives.

Burning hydrogen only produces water as a waste byproduct (as was discovered by Cavendish in 1766). Most hydrogen-powered vehicles are powered by hydrogen fuel cells. These fuel cells facilitate a chemical reaction which is simply a reverse electrolysis reaction, 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.

History of Fuel Cells

In the process of **electrolysis**, water is exposed to an electric current by two electrodes. The result is that water is split into both hydrogen and oxygen gases. The process requires a great deal of electricity however, and the amount of energy gained from the hydrogen gas is usually not worth the amount of energy in the form of electricity that is consumed. It was the process of electrolysis, though, that led to the development of the **first hydrogen fuel cell.**

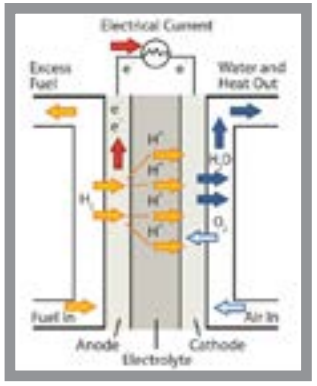
In 1839, the scientist Sir William Grove was considering the electrolysis reaction. Grove knew the combination of water and electricity would yield hydrogen and oxygen gas, as seen below:

$2H_2O$ + electricity $2H_2 + O_2$

Grove reasoned that if the reaction was reversed, in other words oxygen and hydrogen were combined; the reaction would produce water and electricity:

$2H_2 + O_2$ $2H_2O$ + electricity

After several trials, Grove eventually found that if he took two platinum electrodes, placed one in a bottle of oxygen and placed the other in a sealed bottle of hydrogen, he could submerge the bottles in dilute sulfuric acid (acid added to help conduct electrical charge) and a current would flow between the electrodes and water would form in the gas bottles. Grove termed his apparatus a "gas battery." It was rather inefficient and there were other, simpler methods of generating energy at the time, so Grove largely lost interest in his device.



This fuel cell uses H_2 as a fuel and O_2 as the oxidizer.

California opens its first Hydrogen refueling station, located in Santa Monica Blvd.

Make Your Own Fuel Cell

You can make your own hydrogen fuel cell in your classroom lab with **VWR part # 369220** The Hydrogen Fuel Cell Demonstration.

Teach All About Hydrogen with these Hands-on Materials:

Save 13% on these items through February 2016 with promo code EOM16

SAVE 13%

Click item or search by item number to see complete product details and current pricing available at **wardsci.com.**

Hydrogen Fuel Cell Demonstration

Show How Energy is Produced

Your students will be amazed at how easily energy can be produced by combining hydrogen and oxygen to form water. In this demonstration, platinum serves as the catalyst, and electrodes will be prepared by coating metal mesh with the platinum. The hydrogen and oxygen come from electrolysis. After the cell is set up, a brief current is applied with a nine-volt battery, causing the formation of hydrogen gas bubbles on one electrode, and oxygen gas bubbles on the other. Using a voltmeter, electricity produced by the recombining of hydrogen and oxygen, facilitated by the platinum metal catalyst, can be observed. The kit contains enough materials for five demonstrations.

VWR Item Number: 369220

Hydro Car

Just add water to discover the automotive future. This vehicle uses a Polymer Electrolyte Membrane or PEM reversible fuel cell to run on clean hydrogen. Simply add water and observe as hydrogen and oxygen gases are formed in two transparent water containers on the back of the car.

VWR Item Number: 160226

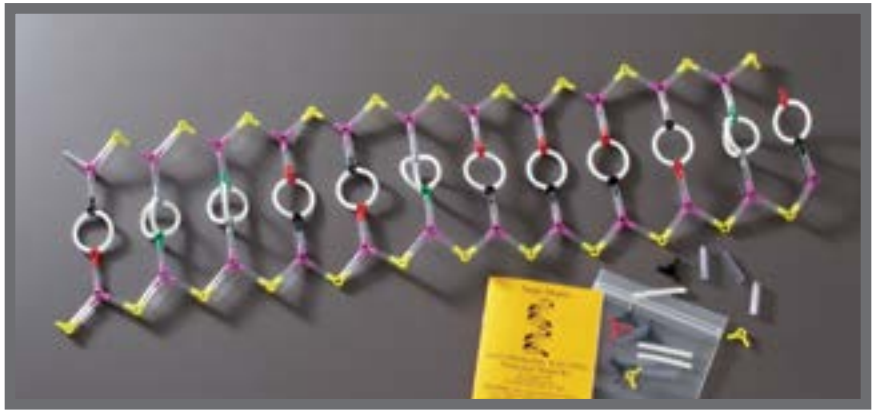
DNA Structure and Protein Synthesis Lab Activity

Understand DNA!

In this lab, students will build a DNA model, and then simulate the replication, transcription, and translation process during protein synthesis. Students will build models of phosphate and sugar separating at the hydrogen bonds that connect the complementary nitrogen bases, as well as attaching anticodons to their complementary codons using hydrogen bond connectors. Understanding these exercises will assist students as they build a DNA molecule and then perform a series of steps to experience how information stored in DNA is expressed as a finished product, and allow them to be exposed to Life Science Framework Standard (LS1), and Physical Science Framework Standard (PS1).

This kit has been aligned with all published National Standards. Pre- and Post-laboratory assessments and vocabulary words all target specific Science and Engineering Practices and common core standards.

VWR Item Number: 366810



DNA SuperModel Kit

Re-create Accurate Bonding Between Base Pairs

Easy to set up, this model is flexible, durable, and economical. The colorful components provide an accurate representation of bonding between base pairs by showing the double bonds between adenine and thymine and the triple bonds between guanine and cytosine. The kit comes with 183 pieces, which is enough to make a 24 nucleotide sequence. Includes an information and instruction booklet.

VWR Item Number: 817100

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

ward's science

Up in Vapor! Hydrogen Peroxide Decomposition

In this experiment you will show the decomposition of the chemical hydrogen peroxide using sodium iodide.

VWR Item Number: 470163-150

Hydrogen Peroxide

H_2O_2 (Aqueous)

F.W.: 34.02 CAS#: 7722-84-1

Shelf Life (months): 12

Soluble: Water and Alcohol

Grade: Reagent ACS, 30%

Storage: Yellow

Please Note: This product is designed for educational and teaching laboratories and no certificate of analysis is available.

VWR Item Number: 470301-282

Ammonia (Household)

Approximately 10% by mass, (~2.3 M).

(NH_3) aqueous

CAS#: 7664-41-7

Hazard: Irritant, Corrosive

Shelf Life (months): 36

Storage: Green

Soluble: Water

bp (°C): 36

Density (g/mL): 1.023

Please Note: This product is designed for educational and teaching laboratories and no certificate of analysis is available.

VWR Item Number: 470300-172