Make a set of flash cards for each of the following elements. Include the name of the element on one side and a picture representing the element on the other side.

The Element Hydrogen

Atomic Number: 1

Atomic Weight: 1.00794

Melting Point: 13.81 K (-259.34°C or -434.81°F)

Boiling Point: 20.28 K (-252.87°C or -423.17°F)

Density: 0.00008988 grams per cubic centimeter

Phase at Room Temperature: Gas

Element Classification: Non-metal

Period Number: 1 **Group Number:** 1 **Group Name:** none

What's in a name? From the Greek words **hydro** and **genes**, which together mean "water forming."

Say what? Hydrogen is pronounced as **HI-dreh-jen**.

History and Uses:

Scientists had been producing hydrogen for years before it was recognized as an element. Written records indicate that Robert Boyle produced hydrogen gas as early as 1671 while experimenting with iron and acids. Hydrogen was first recognized as a distinct element by Henry Cavendish in 1766.

Composed of a single proton and a single electron, hydrogen is the simplest and most abundant element in the universe. It is estimated that 90% of the visible universe is composed of hydrogen.

Hydrogen is the raw fuel that most stars 'burn' to produce energy. The same process, known as fusion, is being studied as a possible power source for use on earth. The sun's supply of hydrogen is expected to last another 5 billion years.

Hydrogen is a commercially important element. Large amounts of hydrogen are combined with nitrogen from the air to produce ammonia (NH_3) through a process called the Haber process. Hydrogen is also added to fats and oils, such as peanut oil, through a process called hydrogenation. Liquid hydrogen is used in the study of superconductors and, when combined with liquid oxygen, makes an excellent rocket fuel.

Hydrogen combines with other elements to form numerous compounds. Some of the common ones are: water (H_2O), ammonia (NH_3), methane (CH_4), table sugar ($C_{12}H_{22}O_{11}$), hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl).

Hydrogen has three common isotopes. The simplest isotope, called protium, is just ordinary hydrogen. The second, a stable isotope called deuterium, was discovered in 1932. The third isotope, tritium, was discovered in 1934.

Estimated Crustal Abundance: 1.40×10^{3} milligrams per kilogram

Estimated Oceanic Abundance: 1.08×10^{5} milligrams per liter

Number of Stable Isotopes: 2 (View all isotope data)

Ionization Energy: 13.598 eV

Oxidation States: +1, -1

Electron Shell Configuration: $1s^1$

The Element Carbon

Atomic Number: 6

Atomic Weight: 12.0107

Melting Point: 3823 K (3550°C or 6422°F)

Boiling Point: 4098 K (3825°C or 6917°F)

Density: 2.2670 grams per cubic centimeter

Phase at Room Temperature: Solid

Element Classification: Non-metal

Period Number: 2 **Group Number:** 14 **Group Name:** none

What's in a name? From the Latin word for charcoal, **carbo**.

Say what? Carbon is pronounced as **KAR-ben**.

History and Uses:

Carbon, the sixth most abundant element in the universe, has been known since ancient times. Carbon is most commonly obtained from coal deposits, although it usually must be processed into a form suitable for commercial use. Three naturally occurring allotropes of carbon are known to exist: amorphous, graphite and diamond.

Amorphous carbon is formed when a material containing carbon is burned without enough oxygen for it to burn completely. This black soot, also known as lampblack, gas black, channel black or carbon black, is used to make inks, paints and rubber products. It can also be pressed into shapes and is used to form the cores of most dry cell batteries, among other things.

Graphite, one of the softest materials known, is a form of carbon that is primarily used as a lubricant. Although it does occur naturally, most commercial graphite is produced by treating petroleum coke, a black tar residue remaining after the refinement of crude oil, in an oxygen-free oven. Naturally occurring graphite occurs in two forms, alpha and beta. These two forms have identical physical properties but different crystal structures. All artificially produced graphite is of the alpha type. In addition to its use as a lubricant, graphite, in a form known as coke, is used in large amounts in the production of steel. Coke is made by heating soft coal in an oven without allowing oxygen to mix with it. Although commonly called lead, the black material used in pencils is actually graphite.

Diamond, the third naturally occurring form of carbon, is one of the hardest substances known. Although naturally occurring diamond is typically used for jewelry, most commercial quality diamonds are artificially produced. These small diamonds are made by squeezing graphite under high temperatures and pressures for several days or weeks and are primarily used to make things like diamond tipped saw blades. Although they posses very different physical properties, graphite and diamond differ only in their crystal structure.

A fourth allotrope of carbon, known as white carbon, was produced in 1969. It is a transparent material that can split a single beam of light into two beams, a property known as birefringence. Very little is known about this form of carbon.

Large molecules consisting only of carbon, known as buckminsterfullerenes, or buckyballs, have recently been discovered and are currently the subject of much scientific interest. A single buckyball consists of 60 or 70 carbon atoms (C_{60} or C_{70}) linked together in a structure that looks like a soccer ball. They can trap other atoms within their framework, appear to be capable of withstanding great pressures and have magnetic and superconductive properties.

Carbon-14, a radioactive isotope of carbon with a half-life of 5,730 years, is used to find the age of formerly living things through a process known as radiocarbon dating. The theory behind carbon dating is fairly simple. Scientists know that a small amount of naturally occurring carbon is carbon-14. Although carbon-14 decays into nitrogen-14 through beta decay, the amount of carbon-14 in the environment remains constant because new carbon-14 is always being created in the upper atmosphere by cosmic rays. Living things tend to ingest materials that contain carbon, so the percentage of carbon-14 within living things is the same as the percentage of carbon-14 in the environment. Once an organism dies, it no longer ingests much of anything. The carbon-14 within that organism is no longer replaced and the percentage of carbon-14 begins to decrease as it decays. By measuring the percentage of carbon-14 in the remains of an organism, and by assuming that the natural abundance of carbon-14 has remained constant over time, scientists can estimate when that organism died. For example, if the concentration of carbon-14 in the remains of an organism is half of the natural concentration of carbon-14, a scientist would estimate that the organism died about 5,730 years ago, the half-life of carbon-14.

There are nearly ten million known carbon compounds and an entire branch of chemistry, known as organic chemistry, is devoted to their study. Many carbon compounds are essential for life as we know it. Some of the most common carbon compounds are: carbon dioxide (CO_2), carbon monoxide (CO), carbon disulfide (CS_2), chloroform ($CHCl_3$), carbon tetrachloride (CCl_4), methane (CH_4), ethylene (C_2H_4), acetylene (C_2H_2), benzene (C_6H_6), ethyl alcohol (C_2H_5OH) and acetic acid (CH_3COOH).

Estimated Crustal Abundance: 2.00×10^{2} milligrams per kilogram

Estimated Oceanic Abundance: 2.8×10^{1} milligrams per liter

Number of Stable Isotopes: 2 (View all isotope data)

Ionization Energy: 11.260 eV

Oxidation States: +4, +2, -4

Electron Shell Configuration: $1s^2$
$2s^2$ $2p^2$

The Element Nitrogen

Atomic Number: 7

Atomic Weight: 14.0067

Melting Point: 63.15 K (-210.00°C or -346.00°F)

Boiling Point: 77.36 K (-195.79°C or -320.44°F)

Density: 0.0012506 grams per cubic centimeter

Phase at Room Temperature: Gas

Element Classification: Non-metal

Period Number: 2 **Group Number:** 15 **Group Name:** Pnictogen

What's in a name? From the Greek words **nitron** and **genes**, which together mean "saltpetre forming."

Say what? Nitrogen is pronounced as **NYE-treh-gen**.

History and Uses:

Nitrogen was discovered by the Scottish physician Daniel Rutherford in 1772. It is the fifth most abundant element in the universe and makes up about 78% of the earth's atmosphere, which contains an estimated 4,000 trillion tons of the gas. Nitrogen is obtained from liquefied air through a process known as fractional distillation.

The largest use of nitrogen is for the production of ammonia (NH_3). Large amounts of nitrogen are combined with hydrogen to produce ammonia in a method known as the Haber process. Large amounts of ammonia are then used to create fertilizers, explosives and, through a process known as the Ostwald process, nitric acid (HNO_3).

Nitrogen gas is largely inert and is used as a protective shield in the semiconductor industry and during certain types of welding and soldering operations. Oil companies use high pressure nitrogen to help force crude oil to the surface. Liquid nitrogen is an inexpensive cryogenic liquid used for refrigeration, preservation of biological samples and for low temperature scientific experimentation. Jefferson Lab's Frostbite Theater features many basic liquid nitrogen experiments.

Estimated Crustal Abundance: 1.9×10^{1} milligrams per kilogram

Estimated Oceanic Abundance: 5×10^{-1} milligrams per liter

Number of Stable Isotopes: 2 (View all isotope data)

Ionization Energy: 14.534 eV

Oxidation States: +5, +4, +3, +2, +1, -1, -2, -3

Electron Shell Configuration: $1s^2$
$2s^2$ $2p^3$

The Element Oxygen

Atomic Number: 8

Atomic Weight: 15.9994

Melting Point: 54.36 K (-218.79°C or -361.82°F)

Boiling Point: 90.20 K (-182.95°C or -297.31°F)

Density: 0.001429 grams per cubic centimeter

Phase at Room Temperature: Gas

Element Classification: Non-metal

Period Number: 2 **Group Number:** 16 **Group Name:** Chalcogen

What's in a name? From the greek words **oxys** and **genes**, which together mean "acid forming."

Say what? Oxygen is pronounced as **OK-si-jen**.

History and Uses:

Oxygen had been produced by several chemists prior to its discovery in 1774, but they failed to recognize it as a distinct element. Joseph Priestley and Carl Wilhelm Scheele both independently discovered oxygen, but Priestly is usually given credit for the discovery. They were both able to produce oxygen by heating mercuric oxide (HgO). Priestley called the gas produced in his experiments 'dephlogisticated air' and Scheele called his 'fire air'. The name oxygen was created by Antoine Lavoisier who incorrectly believed that oxygen was necessary to form all acids.

Oxygen is the third most abundant element in the universe and makes up nearly 21% of the earth's atmosphere. Oxygen accounts for nearly half of the mass of the earth's crust, two thirds of the mass of the human body and nine tenths of the mass of water. Large amounts of oxygen can be extracted from liquefied air through a process known as fractional distillation. Oxygen can also be produced through the electrolysis of water or by heating potassium chlorate ($KClO_3$).

Oxygen is a highly reactive element and is capable of combining with most other elements. It is required by most living organisms and for most forms of combustion. Impurities in molten pig iron are burned away with streams of high pressure oxygen to produce steel. Oxygen can also be combined with acetylene (C_2H_2) to produce an extremely hot flame used for welding. Liquid oxygen, when combined with liquid hydrogen, makes an excellent rocket fuel. Ozone (O_3) forms a thin, protective layer around the earth that shields the surface from the sun's ultraviolet radiation. Oxygen is also a component of hundreds of thousands of organic compounds.

Estimated Crustal Abundance: 4.61×10^5 milligrams per kilogram

Estimated Oceanic Abundance: 8.57×10^5 milligrams per liter

Number of Stable Isotopes: 3 (View all isotope data)

Ionization Energy: 13.618 eV

Oxidation State: -2

Electron Shell Configuration: $1s^2$
$2s^2$ $2p^4$

The Element Phosphorus

30.973762

Atomic Number: 15

Atomic Weight: 30.973762

Melting Point: 317.30 K (44.15°C or 111.47°F)

Boiling Point: 553.65 K (280.5°C or 536.9°F)

Density: 1.82 grams per cubic centimeter

Phase at Room Temperature: Solid

Element Classification: Non-metal

Period Number: 3 **Group Number:** 15 **Group Name:** Pnictogen

What's in a name? From the Greek word for light bearing, **phosphoros**.

Say what? Phosphorus is pronounced as **FOS-fer-es**.

History and Uses:

In what is perhaps the most disgusting method of discovering an element, phosphorus was first isolated in 1669 by Hennig Brand, a German physician and alchemist, by boiling, filtering and otherwise processing as many as 60 buckets of urine. Thankfully, phosphorus is now primarily obtained from phosphate rock ($Ca_3(PO_4)_2$).

Phosphorus has three main allotropes: white, red and black. White phosphorus is poisonous and can spontaneously ignite when it comes in contact with air. For this reason, white phosphorus must be stored under water and is usually used to produce phosphorus compounds. Red phosphorus is formed by heating white phosphorus to 250°C (482°F) or by exposing white phosphorus to sunlight. Red phosphorus is not poisonous and is not as dangerous as white phosphorus, although frictional heating is enough to change it back to white phosphorus. Red phosphorus is used in safety matches, fireworks, smoke bombs and pesticides. Black phosphorus is also formed by heating white phosphorus, but a mercurycatalyst and a seed crystal of black phosphorus are required. Black phosphorus is the least reactive form of phosphorus and has no significant commercial uses.

Phosphoric acid (H_3PO_4) is used in soft drinks and to create many phosphate compounds, such as triple superphosphate fertilizer ($Ca(H_2PO_4)_2{\cdot}H_2O$). Trisodium phosphate (Na_3PO_4) is used as a cleaning agent and as a water softener. Calcium phosphate ($Ca_3(PO_4)_2$) is used to make china and in the production of baking powder. Some phosphorus compounds glow in the dark or emit light in response to absorbing radiation and are used in fluorescent light bulbs and television sets.

Estimated Crustal Abundance: 1.05×10^3 milligrams per kilogram

Estimated Oceanic Abundance: 6×10^{-2} milligrams per liter

Number of Stable Isotopes: 1 (View all isotope data)

Ionization Energy: 10.487 eV

Oxidation States: +5, +3, -3

Electron Shell Configuration: $1s^2$
$2s^2$ $2p^6$
$3s^2$ $3p^3$

The Element Sulfur

Atomic Number: 16

Atomic Weight: 32.065

Melting Point: 388.36 K (115.21°C or 239.38°F)

Boiling Point: 717.75 K (444.60°C or 832.28°F)

Density: 2.067 grams per cubic centimeter

Phase at Room Temperature: Solid

Element Classification: Non-metal

Period Number: 3 **Group Number:** 16 **Group Name:** Chalcogen

What's in a name? From the Sanskrit word **sulvere** and the Latin word **sulphurium**.

Say what? Sulfur is pronounced as **SUL-fer**.

History and Uses:

Sulfur, the tenth most abundant element in the universe, has been known since ancient times. Sometime around 1777, Antoine Lavoisier convinced the rest of the scientific community that sulfur was an element. Sulfur is a component of many common minerals, such as galena (PbS), gypsum ($CaSO_4 \cdot 2(H_2O)$), pyrite (FeS_2), sphalerite (ZnS or FeS), cinnabar (HgS), stibnite (Sb_2S_3), epsomite ($MgSO_4 \cdot 7(H_2O)$), celestite ($SrSO_4$) and barite ($BaSO_4$). Nearly 25% of the sulfur produced today is recovered from petroleum refining operations and as a byproduct of extracting other materials from sulfur containing ores. The majority of the sulfur produced today is obtained from underground deposits, usually found in conjunction with salt deposits, with a process known as the Frasch process.

Sulfur is a pale yellow, odorless and brittle material. It displays three allotropic forms: orthorhombic, monoclinic and amorphous. The orthorhombic form is the most stable form of sulfur. Monoclinic sulfur exists between the temperatures of 96°C and 119°C and reverts back to the orthorhombic form when cooled. Amorphous sulfur is formed when molten sulfur is quickly cooled. Amorphous sulfur is soft and elastic and eventually reverts back to the orthorhombic form.

Most of the sulfur that is produced is used in the manufacture of sulfuric acid (H_2SO_4). Large amounts of sulfuric acid, nearly 40 million tons, are used each year to make fertilizers, lead-acid batteries, and in many industrial processes. Smaller amounts of sulfur are used to vulcanize natural rubbers, as an insecticide (the Greek poet Homer mentioned "pest-averting sulphur" nearly 2,800 years ago!), in the manufacture of gunpowder and as a dying agent.

In addition to sulfuric acid, sulfur forms other interesting compounds. Hydrogen sulfide (H_2S) is a gas that smells like rotten eggs. Sulfur dioxide (SO_2), formed by burning sulfur in air, is used as a bleaching agent, solvent, disinfectant and as a refrigerant. When combined with water (H_2O), sulfur dioxide forms sulfurous acid (H_2SO_3), a weak acid that is a major component of acid rain.

Estimated Crustal Abundance: 3.50×10^2 milligrams per kilogram

Estimated Oceanic Abundance: 9.05×10^2 milligrams per liter

Number of Stable Isotopes: 4 (View all isotope data)

Ionization Energy: 10.360 eV

Oxidation States: +6, +4, -2

Electron Shell Configuration: $1s^2$
$2s^2$ $2p^6$
$3s^2$ $3p^4$