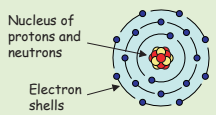
# The Periodic Table of the Elements, in Words

**Hydrogen** belongs to no definite group. It forms compounds by either donating an electron like an alkali metal or accepting an electron like a halogen.

**Alkali Metals** are very reactive and readily form compounds but are not found free in nature. They form salts and **alkali** (acid-neutralizing) compounds such as baking soda. In pure form, they are very soft metals which catch fire on contact with water.

**Alkali Earth Metals** are reactive and readily form compounds but are not found free in nature. Their oxides are called **alkali earths**. In pure form, they are soft and somewhat brittle metals.

## Atoms




An **atom** has a **nucleus**, made of **protons** and **neutrons**, surrounded by **electrons** orbiting in cloud-like **shells**. Smaller shells are surrounded by larger shells.

The **atomic number** is the number of protons in an atom. This determines the chemical properties of the atom.

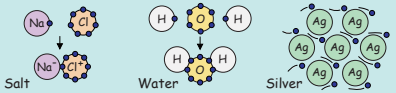
Protons have positive **electric charge**, neutrons are neutral, and electrons are negative. Normally, an atom has equal numbers of protons and electrons. An **ion** is a charged atom with more or fewer electrons than protons.

The **atomic weight** of an element is the average number of protons plus neutrons. You can easily estimate the atomic weight: it is usually 2 to 2.5 times the atomic number.

An **element** is a substance made from one or more atoms of the same atomic number. A **compound** is a substance made from two or more elements chemically bonded.

## Chemical Bonding

Atoms form **molecules** by **bonding** together. Atoms give, take, or share electrons to achieve full outer electron shells.




**Ionic bond**
One atom takes an electron from another atom and the oppositely charged ions attract.

**Covalent bond**
Atoms share their outer electrons.

**Metallic bond**
Shared outer electrons flow, conducting heat and electricity.

## Groups

Elements in the same **group**, or column, are similar because they typically have the same number of outer electrons. This table shows some easy-to-remember common numbers for each group.

| Group number | 1 | 2 | 3-12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| Outer electrons* | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Valence number* | +1 | +2 | +2 | +3 | +4,-4 | -3 | -2 | -1 | 0 |

* typical — The valence number is the number of electrons given (+) or taken (-) when bonding.

**Metalloids** are partly like metals and partly like non-metals. For example, they are semiconductors, which means they conduct electricity in some conditions.

**Nonmetals**, in their solid state, are usually brittle (they break rather than bend) and they are insulators of both heat and electricity.

**Halogens** are reactive nonmetals and readily form compounds but are not found free in nature. They combine with alkali metals to form salts (halogen means salt-former).

**Noble Gases** are inactive, or inert. Each atom has exactly the number of electrons it needs to have a full outer shell, so these atoms almost never bond with other atoms. That is why these are all gases.

**Transition Metals** are typical metals: they are strong, shiny, malleable (they can be hammered into shape), flexible (in thin sheets or wires), and they conduct both heat and electricity.

**Poor Metals** are usually soft and have low melting temperatures.

| Periods | Group 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H Hydrogen 1<br>explosive gas, lightest element; 90% of atoms in the universe, sun and stars, water ($H_2O$), life's organic molecules | | | | | | | | | | | | | | | | | He Helium 2<br>inert gas, second lightest element; fuel for nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant |
| 2 | Li Lithium 3<br>lightest metal, soft, reactive; lightweight aluminum alloys, batteries, impact-resistant ceramic cookware, mood stabilizer | Be Beryllium 4<br>lightweight metal; non-sparking copper alloy tools, aerospace, X-ray windows, beryl gems: emeralds and aquamarines | | | | | | | | | | | B Boron 5<br>hard black solid; borax soap, fertilizer, stiff fibers, sports equipment, heat-resistant borosilicate glass, semiconductors | C Carbon 6<br>hard diamond, soft graphite; basis of life's organic molecules, animals, plants, $CO_2$, wood, paper, cloth, plastic, coal, oil, gasoline | N Nitrogen 7<br>colorless gas; 78% of air, organic molecules, protein, muscles, DNA, ammonia, fertilizer, explosives (TNT), refrigerants | O Oxygen 8<br>colorless gas; 21% of air, $H_2O$, 65% of the body, organic molecules, blood, breathing, fire, half of earth's crust, minerals, oxides | F Fluorine 9<br>yellowish poison gas, most reactive element; glowing fluorite, toothpaste, nonstick cookware, CFC refrigerants | Ne Neon 10<br>inert gas; orange-red neon tubes for advertising signs, lasers, supercold refrigerant |
| 3 | Na Sodium 11<br>soft metal, reactive; salt (NaCl), nerves, baking soda, antacids, lye, soap, soda ash, glass, papermaking, street lamps | Mg Magnesium 12<br>lightweight metal; chlorophyll in green plants, talc, basalt, aluminum alloys, cars, planes, bikes, flares, sparklers, antacids | | | | | | | | | | | Al Aluminum 13<br>lightweight non-corroding metal; kitchenware, cans, foil, machinery, cars, planes, bikes, feldspar, granite, clay, ceramics, corundum, gems | Si Silicon 14<br>hard metalloid; quartz, granite, sand, soil, clay, ceramics, glass, algae, diatoms, semiconductors, computer chips, silicone rubber | P Phosphorus 15<br>glowing white waxy solid (also red and black forms); bones, DNA, energy-storing phosphates (ATP), fertilizer, acids, detergent, matches | S Sulfur 16<br>brittle yellow solid; skin, hair, egg yolks, onions, garlic, skunks, hot springs, volcanos, gypsum, rubber, acids, papermaking | Cl Chlorine 17<br>greenish poison gas; salt (NaCl), bleach, stomach acid, disinfectant, drinking water, swimming pools, PVC plastic pipes and bottles | Ar Argon 18<br>inert gas; 1% of air, most abundant inert gas, light bulbs, "neon" tubes, lasers, welding gas |
| 4 | K Potassium 19<br>soft metal, reactive; salts, nerves, nutrients in fruits and vegetables, soap, fertilizer, potash, matches, gunpowder | Ca Calcium 20<br>soft metal; bones, teeth, milk, leaves, vegetables, shells, coral, limestone, chalk, gypsum, plaster, mortar, cement, marble, antacids | Sc Scandium 21<br>soft lightweight metal; aluminum alloys, racing bikes, stadium lamps, furnace bricks, aquamarines | Ti Titanium 22<br>strongest lightweight metal, heat-resistant; aerospace, racing bikes, artificial joints, white paint, blue sapphires | V Vanadium 23<br>hard metal; hard strong resilient steel, structures, vehicles, springs, driveshafts, tools, aerospace, violet sapphires | Cr Chromium 24<br>hard shiny metal; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, car trim, paints, recording tape, emeralds & rubies | Mn Manganese 25<br>hard metal; hard tough steel, earthmovers, rock crushers, rails, plows, axes, batteries, fertilizer, amethysts | Fe Iron 26<br>medium-hard metal, magnetic; steel alloys are mostly iron, structures, vehicles, magnets, earth's core, red rocks, blood | Co Cobalt 27<br>hard metal, magnetic; hard strong steel, cutting tools, turbines, magnets (Al-Ni-Co), blue glass, ceramics, vitamin B-12 | Ni Nickel 28<br>medium-hard metal, magnetic; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, nicad batteries, coins, earth's core | Cu Copper 29<br>colored metal, conducts heat and electricity well; wires, cookware, brass (Cu-Zn), bronze (Cu-Sn), coins, pipes, blue crab blood | Zn Zinc 30<br>non-corroding metal; galvanized steel, brass (Cu-Zn), batteries, white paint, phosphors in TVs and lamps, fertilizer | Ga Gallium 31<br>soft metal, melts on a hot day; semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, tiny lasers | Ge Germanium 32<br>brittle metalloid; semiconductors, transistors, rectifiers, diodes, photocells, lenses, infrared windows | As Arsenic 33<br>brittle metalloid; poisons, semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, tiny lasers | Se Selenium 34<br>brittle gray solid; photocopiers, laser printers, photocells, red glass, dandruff shampoo, rubber | Br Bromine 35<br>dark red liquid; disinfectant, pools and spas, photo film, flame retardant, leaded gasoline, sedatives | Kr Krypton 36<br>inert gas; high-intensity lamps, headlights, flashlights, lanterns, "neon" tubes, lasers |
| 5 | Rb Rubidium 37<br>soft metal, reactive; atomic clocks, global navigation (GPS), vacuum tube scavenger | Sr Strontium 38<br>soft metal; red fireworks, flares, phosphors, nuclear batteries, medical diagnostic tracer, nuclear fallout | Y Yttrium 39<br>soft metal; phosphors in color TVs, lasers (YAG, YLF), furnace bricks, high-temperature superconductors | Zr Zirconium 40<br>non-corroding neutron-resistant metal; chemical pipelines, nuclear reactors, furnace bricks, abrasives, zircon gems | Nb Niobium 41<br>high-melting-point non-corroding metal; chemical pipelines, superconductors, magnetic levitation trains, MRI magnets | Mo Molybdenum 42<br>high-melting-point metal; hard steel, cutting tools, drill bits, armor plate, gun barrels, fertilizer | Tc Technetium 43<br>radioactive, long-lived; first human-made element, only traces on earth but found in stars, medical diagnostic tracer | Ru Ruthenium 44<br>non-corroding hard metal; electric contacts, leaf switches, pen tips, catalyst, hydrogen production | Rh Rhodium 45<br>non-corroding hard shiny metal; labware, reflectors, electric contacts, thermocouples, catalyst, pollution control | Pd Palladium 46<br>non-corroding hard metal, absorbs hydrogen; labware, electric contacts, dentistry, catalyst, pollution control | Ag Silver 47<br>soft shiny metal, conducts electricity best of all elements; jewelry, silverware, coins, dentistry, photo film | Cd Cadmium 48<br>non-corroding soft metal, toxic; electroplated steel, nicad batteries, red and yellow paints, fire sprinklers | In Indium 49<br>soft metal; solders, glass seals, glass coatings, liquid crystal displays (LCDs), semiconductors, diodes, photocells | Sn Tin 50<br>non-corroding soft metal; solders, plated food cans, bronze (Cu-Sn), pewter cups, glassmaking, fire sprinklers | Sb Antimony 51<br>brittle metalloid; solders, lead hardener, batteries, bullets, semiconductors, photocells, matches, flame retardant | Te Tellurium 52<br>brittle metalloid; alloys, semiconductors, photocopiers, computer disks, thermo-electric coolers and generators | I Iodine 53<br>violet-black solid, disinfectant for wounds and drinking water, added to salt to prevent thyroid disease, photo film | Xe Xenon 54<br>inert gas; high-intensity lamps, headlights, stadium lamps, projectors, strobes, lasers, spacecraft ion engines |
| 6 | Cs Cesium 55<br>soft metal, melts on a hot day, reactive, largest stable atoms; atomic clocks, global navigation (GPS), vacuum tube scavenger | Ba Barium 56<br>soft metal, absorbs X-rays; stomach X-ray contrast enhancer, green firworks, whitener and filler for paper, plastic, and rubber | 57 - 71<br>Rare Earth Metals | Hf Hafnium 72<br>non-corroding metal, absorbs neutrons; nuclear reactor control rods in submarines, plasma torch electrodes | Ta Tantalum 73<br>high-melting-point non-corroding metal; labware, surgical tools, artificial joints, capacitors, mobile phones | W Tungsten 74<br>highest-melting-point metal, dense; filaments in lamps and TVs, cutting tools, abrasives, thermocouples | Re Rhenium 75<br>high-melting-point dense metal; rocket engines, heater coils, lab filaments, electric contacts, thermocouples, catalyst | Os Osmium 76<br>non-corroding high-melting-point hard metal, densest element (same as iridium); electric contacts, pen tips, needles, fingerprint powder | Ir Iridium 77<br>non-corroding hard metal, densest element (same as osmium); labware, spark plugs, pen tips, needles | Pt Platinum 78<br>non-corroding dense metal; labware, spark plugs, catalyst, pollution control, petroleum cracking, processing fats | Au Gold 79<br>most malleable element, dense non-tarnishing colored metal; jewelry, coins, ultra-thin gold leaf, electric contacts | Hg Mercury 80<br>liquid metal, toxic; thermometers, barometers, thermostats, street lamps, fluorescent lamps, dentistry | Tl Thallium 81<br>soft metal, toxic; low-melting-point mercury alloys, low-temperature thermometers, undersea lamps, photocells | Pb Lead 82<br>dense, soft, non-corroding metal, toxic; weights, solders, batteries, bullets, crystal glass, old plumbing, radiation shield | Bi Bismuth 83<br>low-melting-point brittle metal; solders, fuses, fire sprinklers (plugs melt when hot), cosmetics pigment | Po Polonium 84<br>radioactive, long-lived; first radioactive element found, small traces in nature, anti-static brushes, tobacco | At Astatine 85<br>radioactive, short-lived; small traces in nature, cancer medicine | Rn Radon 86<br>radioactive gas, short-lived; environmental hazard, surgical implants for cancer treatment |
| 7 | Fr Francium 87<br>radioactive, short-lived atoms larger than cesium; small traces in nature, studied in laser atom traps | Ra Radium 88<br>radioactive, long-lived; luminous watches (now banned), medical radon production, radiography, radwaste | 89 - 103<br>Actinide Metals | Rf 104<br>Rutherfordium | Db 105<br>Dubnium | Sg 106<br>Seaborgium | Bh 107<br>Bohrium | Hs 108<br>Hassium | Mt 109<br>Meitnerium | Ds 110<br>Darmstadtium | Rg 111<br>Roentgenium | 112 | 113 | 114 | 115 | 116 | 117 | 118 |
| 8 | 119 | 120 | 121 - 153 | Superheavy Elements<br>radioactive, short-lived; never found in nature, no uses except atomic research | | | | | | | | | | | | | | |

| | La Lanthanum 57<br>soft metal; optical glass, telescope eyepieces, camera lenses, lighter flints, arc lamps | Ce Cerium 58<br>soft metal; most abundant rare earth metal, lighter flints, gas lamp mantles, self-cleaning ovens, glass polishing | Pr Praseodymium 59<br>soft metal; torchworkers' didymium eye-glasses (Pr-Nd), lighter flints, arc lamps, magnets, yellow glass | Nd Neodymium 60<br>soft metal; strong magnets (Nd-Fe-B), electric motors, speakers and headphones, lasers, lighter flints | Pm Promethium 61<br>radioactive, long-lived; human-made, small traces in nature, luminous dials, sheet thickness gauges | Sm Samarium 62<br>soft metal; magnets (Sm-Co), electric motors, speakers and headphones, infrared sensors, infrared-absorbing glass | Eu Europium 63<br>soft metal; phosphors in color TVs and trichromatic lamps, luminous paint, lasers | Gd Gadolinium 64<br>soft metal, best neutron absorber, magnetic; magnetic resonance imaging (MRI) contrast enhancer, phosphors, neutron radiography | Tb Terbium 65<br>soft metal; phosphors in color TVs and trichromatic lamps, computer disks, magnetostrictive smart materials (Terfenol-D®) | Dy Dysprosium 66<br>soft metal; nuclear control rods, MRI phosphors, computer disks, magnetostrictive smart materials (Terfenol-D®) | Ho Holmium 67<br>soft metal; infrared lasers, laser surgery, eye-safe laser rangefinders, computer disks, yellow glass filters | Er Erbium 68<br>soft metal; fiber optic signal amplifiers, infrared lasers, laser surgery, pink glass, sunglasses, vanadium alloys | Tm Thulium 69<br>soft metal; rarest stable rare earth metal, infrared lasers, laser surgery, phosphors | Yb Ytterbium 70<br>soft metal; fiber optic signal amplifiers, infrared fiber lasers, stainless steel alloys | Lu Lutetium 71<br>soft metal, densest and hardest rare earth metal; cancer-fighting photodynamic (light-activated) medicine |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ac Actinium 89<br>radioactive, long-lived; small traces in nature, cancer medicine, neutron source, radwaste | Th Thorium 90<br>radioactive, long-lived; most abundant radioactive element, nuclear reactor fuel, gas lamp mantles, tungsten filaments | Pa Protactinium 91<br>radioactive, long-lived; small traces in nature, no uses, radwaste | U Uranium 92<br>radioactive, long-lived, dense; nuclear reactor fuel, nuclear weapons, counterweights, armor piercing bullets | Np Neptunium 93<br>radioactive, long-lived; small traces in nature, neutron detectors, dosimeters, nuclear weapons, radwaste | Pl Plutonium 94<br>radioactive, long-lived; small traces in nature, nuclear reactor fuel, nuclear weapons, radwaste | Am Americium 95<br>radioactive, long-lived; never found in nature, smoke detectors, sheet thickness gauges, radwaste | Cm Curium 96<br>radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste | Bk Berkelium 97<br>radioactive, long-lived; never found in nature, no uses, radwaste | Cf Californium 98<br>radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste | Es 99<br>Einsteinium | Fm 100<br>Fermium | Md 101<br>Mendelevium | No 102<br>Nobelium | Lr 103<br>Lawrencium |
| | | | | | | | | | | | | | | | | | | |

**Rare Earth Metals** are all soft metals. They are chemically similar to scandium and yttrium and are difficult to separate from each other.

**Actinide Metals** are all radioactive heavy metals. They are used mainly for their radioactive properties.

**Radioactivity.** Atoms with the same number of protons but different numbers of neutrons are called **isotopes**. Some isotopes are **stable**; others are **radioactive** — their nuclei eventually **disintegrate**. The radioactive **half-life** is the time for half the nuclei to disintegrate. On this chart, an element is called **long-lived** if the half-life of any of its isotopes is more than one year; otherwise it is called **short-lived**.

What is the last human-made element? For up-to-date information, search the web for "periodic table".

**elements.wlonk.com**

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