The Periodic Table of the Elements, in Pictures

Periods

Alkali Metals Group 1 | Alkali Earth Metals 2 | Transition Metals 3–12 | Boron Group 13 | Carbon Group 14 | Nitrogen Group 15 | Oxygen Group 16 | Halogens 17 | Noble Gases 18

1 — H Hydrogen 1 (Sun and Stars); He Helium 2 (Balloons)

2 — Li Lithium 3 (Batteries); Be Beryllium 4 (Emeralds); B Boron 5 (Sports Equipment); C Carbon 6 (Basis of Life's Molecules); N Nitrogen 7 (Protein); O Oxygen 8 (Air); F Fluorine 9 (Toothpaste); Ne Neon 10 (Advertising Signs)

3 — Na Sodium 11 (Salt); Mg Magnesium 12 (Chlorophyll); Al Aluminum 13 (Airplanes); Si Silicon 14 (Stone, Sand, and Soil); P Phosphorus 15 (Bones); S Sulfur 16 (Eggs); Cl Chlorine 17 (Swimming Pools); Ar Argon 18 (Light Bulbs)

4 — K Potassium 19 (Fruits and Vegetables); Ca Calcium 20 (Shells and Bones); Sc Scandium 21 (Bicycles); Ti Titanium 22 (Aerospace); V Vanadium 23 (Springs); Cr Chromium 24 (Stainless Steel); Mn Manganese 25 (Earthmovers); Fe Iron 26 (Steel Structures); Co Cobalt 27 (Magnets); Ni Nickel 28 (Coins); Cu Copper 29 (Electric Wires); Zn Zinc 30 (Brass Instruments); Ga Gallium 31 (Light-Emitting Diodes (LEDs)); Ge Germanium 32 (Semiconductor Electronics); As Arsenic 33 (Poison); Se Selenium 34 (Copiers); Br Bromine 35 (Photography Film); Kr Krypton 36 (Flashlights)

5 — Rb Rubidium 37 (Global Navigation); Sr Strontium 38 (Fireworks); Y Yttrium 39 (Lasers); Zr Zirconium 40 (Chemical Pipelines); Nb Niobium 41 (Mag Lev Trains); Mo Molybdenum 42 (Cutting Tools); Tc Technetium 43 (Radioactive Diagnosis); Ru Ruthenium 44 (Electric Switches); Rh Rhodium 45 (Searchlight Reflectors); Pd Palladium 46 (Pollution Control); Ag Silver 47 (Jewelry); Cd Cadmium 48 (Paint); In Indium 49 (Liquid Crystal Displays (LCDs)); Sn Tin 50 (Plated Food Cans); Sb Antimony 51 (Car Batteries); Te Tellurium 52 (Thermoelectric Coolers); I Iodine 53 (Disinfectant); Xe Xenon 54 (High-Intensity Lamps)

6 — Cs Cesium 55 (Atomic Clocks); Ba Barium 56 (X-Ray Diagnosis); 57 - 71 Rare Earth Metals; Hf Hafnium 72 (Nuclear Submarines); Ta Tantalum 73 (Mobile Phones); W Tungsten 74 (Lamp Filaments); Re Rhenium 75 (Rocket Engines); Os Osmium 76 (Pen Points); Ir Iridium 77 (Spark Plugs); Pt Platinum 78 (Labware); Au Gold 79 (Jewelry); Hg Mercury 80 (Thermometers); Tl Thallium 81 (Low-Temperature Thermometers); Pb Lead 82 (Weights); Bi Bismuth 83 (Fire Sprinklers); Po Polonium 84 (Anti-Static Brushes); At Astatine 85 (Radioactive Medicine); Rn Radon 86 (Surgical Implants)

7 — Fr Francium 87 (Laser Atom Traps); Ra Radium 88 (Luminous Watches); 89 - 103 Actinide Metals; Rf Rutherfordium 104; Db Dubnium 105; Sg Seaborgium 106; Bh Bohrium 107; Hs Hassium 108; Mt Meitnerium 109; Ds Darmstadtium 110; Rg Roentgenium 111; Cn Copernicium 112; Nh Nihonium 113; Fl Flerovium 114; Mc Moscovium 115; Lv Livermorium 116; Ts Tennessine 117; Og Oganesson 118

Superheavy Elements — radioactive, never found in nature, no uses except atomic research

8 — 119; 120; 121...

Rare Earth Metals: La Lanthanum 57 (Telescope Lenses); Ce Cerium 58 (Lighter Flints); Pr Praseodymium 59 (Torchworkers' Eyeglasses); Nd Neodymium 60 (Electric Motor Magnets); Pm Promethium 61 (Luminous Dials); Sm Samarium 62 (Electric Motor Magnets); Eu Europium 63 (Color Televisions); Gd Gadolinium 64 (MRI Diagnosis); Tb Terbium 65 (Fluorescent Lamps); Dy Dysprosium 66 (Smart Material Actuators); Ho Holmium 67 (Laser Surgery); Er Erbium 68 (Optical Fiber Communications); Tm Thulium 69 (Laser Surgery); Yb Ytterbium 70 (Scientific Fiber Lasers); Lu Lutetium 71 (Photodynamic Medicine)

Actinide Metals: Ac Actinium 89 (Radioactive Medicine); Th Thorium 90 (Gas Lamp Mantles); Pa Protactinium 91 (Radioactive Waste); U Uranium 92 (Nuclear Power); Np Neptunium 93 (Radioactive Waste); Pu Plutonium 94 (Nuclear Weapons); Am Americium 95 (Smoke Detectors); Cm Curium 96 (Mineral Analyzers); Bk Berkelium 97 (Radioactive Waste); Cf Californium 98 (Mineral Analyzers); Es Einsteinium 99; Fm Fermium 100; Md Mendelevium 101; No Nobelium 102; Lr Lawrencium 103

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Atomic Symbol, Atomic Number (number of protons), Symbols, Name, Widgets — How it is (or was) used or where it occurs in nature

Solid; Liquid; Gas at room temperature. The color of the symbol is the color of the element in its most common pure form. Examples: metallic solid; red liquid; colorless gas

Human Body — top ten elements by weight
Earth's Crust — top eight elements by weight
Magnetic — ferromagnetic at room temperature
Noble Metals — corrosion-resistant
Radioactive — all isotopes are radioactive
Only Traces Found in Nature — less than a millionth percent of earth's crust
Never Found in Nature — only made by people

Color Key: Metals — Nonmetals; H; Alkali Metals; Alkali Earth Metals; Transition Metals; Nonmetals; Metalloids; Poor Metals; Halogens; Noble Gases; Superheavy Elements; Rare Earth Metals; Actinide Metals

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.

Group 1 | 2 | 3–12 | 13 | 14 | 15 | 16 | 17 | 18

Periods

1 — H Hydrogen 1: explosive gas, lightest element; 90% of atoms in the universe, sun and stars, water (H_2O), life's organic molecules

2 — Li Lithium 3: lightest metal, soft, reactive; lightweight aluminum alloys, batteries, impact-resistant ceramic cookware, mood stabilizer; Be Beryllium 4: lightweight metal; non-sparking copper alloy tools, aerospace, X-ray windows, beryl gems: emeralds and aquamarines; B Boron 5: hard black solid; borax soap, fertilizer, stiff fibers, sports equipment, heat-resistant borosilicate glass, semiconductors; C Carbon 6: hard diamond, soft graphite; basis of life's organic molecules, animals, plants, CO_2, wood, paper, cloth, plastic, coal, oil, gasoline; N Nitrogen 7: colorless gas; 78% of air, organic molecules, protein, muscles, DNA, ammonia, fertilizer, explosives (TNT), refrigerants; O Oxygen 8: 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: yellowish poison gas, most reactive element; glowing fluorite, toothpaste, nonstick cookware, CFC refrigerants; Ne Neon 10: inert gas; orange-red neon tubes for advertising signs, lasers, supercold refrigerant

3 — Na Sodium 11: soft metal, reactive; salt (NaCl), nerves, baking soda, antacids, lye, soap, soda ash, glass, papermaking, street lamps; Mg Magnesium 12: lightweight metal; chlorophyll in green plants, talc, basalt, aluminum alloys, cars, planes, bikes, flares, sparklers, antacids; Al Aluminum 13: lightweight non-corroding metal; kitchenware, cans, foil, machinery, cars, planes, bikes, feldspar, granite, clay, ceramics, corundum, gems; Si Silicon 14: hard metalloid; quartz, granite, sand, soil, clay, ceramics, glass, algae, diatoms, semiconductors, computer chips, silicone rubber; P Phosphorus 15: glowing white waxy solid (also red and black forms); bones, DNA, energy-storing phosphates (ATP), fertilizer, acids, detergent, matches; S Sulfur 16: brittle yellow solid; skin, hair, eggs, onions, garlic, skunks, hot springs, volcanos, gypsum, rubber, acids, papermaking; Cl Chlorine 17: greenish poison gas; salt (NaCl), bleach, stomach acid, disinfectant, drinking water, swimming pools, PVC plastic pipes and bottles; Ar Argon 18: inert gas; 1% of air, most abundant inert gas, light bulbs, "neon" tubes, lasers, welding gas

4 — K Potassium 19: soft metal, reactive; salts, nerves, nutrients in fruits and vegetables, soap, fertilizer, potash, matches, gunpowder; Ca Calcium 20: soft metal; bones, teeth, milk, leaves, vegetables, shells, coral, limestone, chalk, gypsum, plaster, mortar, cement, marble, antacids; Sc Scandium 21: soft lightweight metal; aluminum alloys, racing bikes, stadium lamps, furnace bricks, aquamarines; Ti Titanium 22: strongest lightweight metal, heat-resistant; aerospace, racing bikes, artificial joints, white paint, blue sapphires; V Vanadium 23: hard metal; hard strong resilient steel, structures, vehicles, springs, driveshafts, tools, aerospace, violet sapphires; Cr Chromium 24: hard shiny metal; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, car trim, paints, recording tape, emeralds & rubies; Mn Manganese 25: hard metal; hard tough steel, earthmovers, rock crushers, rails, plows, axes, batteries, fertilizer, amethysts; Fe Iron 26: medium-hard metal, magnetic; steel alloys are mostly iron, structures, vehicles, magnets, Earth's core, red rocks, blood; Co Cobalt 27: hard metal, magnetic; hard strong steel, cutting tools, turbines, magnets (Al-Ni-Co), blue glass, ceramics, vitamin B-12; Ni Nickel 28: medium-hard metal, magnetic; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, nicad batteries, coins, Earth's core; Cu Copper 29: colored metal, conducts heat and electricity well; wires, cookware, brass (Cu-Zn), bronze (Cu-Sn), coins, pipes, blue crab blood; Zn Zinc 30: non-corroding metal; galvanized steel, brass (Cu-Zn), batteries, white paint, phosphors in TVs and lamps, fertilizer; Ga Gallium 31: soft metal, melts on a hot day; semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, tiny lasers; Ge Germanium 32: brittle metalloid; semiconductors, transistors, rectifiers, diodes, photocells, lenses, infrared windows; As Arsenic 33: brittle metalloid; poisons, semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, tiny lasers; Se Selenium 34: brittle gray solid; photocopiers, laser printers, photocells, red glass, dandruff shampoo, rubber; Br Bromine 35: dark red liquid; disinfectant, pools and spas, photo film, flame retardant, leaded gasoline, sedatives; Kr Krypton 36: inert gas; high-intensity lamps, headlights, flashlights, lanterns, "neon" tubes, lasers

5 — Rb Rubidium 37: soft metal, reactive; atomic clocks, global navigation (GPS), vacuum tube scavenger; Sr Strontium 38: soft metal; red fireworks, flares, phosphors, nuclear batteries, medical diagnostic tracer, nuclear fallout; Y Yttrium 39: soft metal; phosphors in color TVs, lasers (YAG, YLF), furnace bricks, high-temperature superconductors; Zr Zirconium 40: non-corroding neutron-resistant metal; chemical pipelines, nuclear reactors, furnace bricks, abrasives, zircon gems; Nb Niobium 41: high-melting-point non-corroding metal; chemical pipelines, superconductors, magnetic levitation trains, MRI magnets; Mo Molybdenum 42: high-melting-point metal; hard steel, cutting tools, drill bits, armor plate, gun barrels, fertilizer; Tc Technetium 43: radioactive, long-lived; first human-made element, only traces on Earth but found in stars, medical diagnostic tracer; Ru Ruthenium 44: non-corroding hard metal; electric contacts, leaf switches, pen tips, catalyst, hydrogen production; Rh Rhodium 45: non-corroding hard shiny metal; labware, reflectors, electric contacts, thermocouples, catalyst, pollution control; Pd Palladium 46: non-corroding hard metal, absorbs hydrogen; labware, electric contacts, dentistry, catalyst, pollution control; Ag Silver 47: soft shiny metal, conducts electricity best of all elements; jewelry, silverware, coins, dentistry, photo film; Cd Cadmium 48: non-corroding soft metal, toxic; electroplated steel, nicad batteries, red and yellow paints, fire sprinklers; In Indium 49: soft metal; solders, glass seals, glass coatings, liquid crystal displays (LCDs), semiconductors, diodes, photocells; Sn Tin 50: non-corroding soft metal; solders, plated food cans, bronze (Cu-Sn), pewter cups, glassmaking, fire sprinklers; Sb Antimony 51: brittle metalloid; solders, lead hardener, batteries, bullets, semiconductors, photocells, matches, flame retardant; Te Tellurium 52: brittle metalloid; alloys, semiconductors, photocopiers, computer disks, thermo-electric coolers and generators; I Iodine 53: violet-black solid; disinfectant for wounds and drinking water, added to salt to prevent thyroid disease, photo film; Xe Xenon 54: inert gas; high-intensity lamps, headlights, stadium lamps, projectors, strobes, lasers, spacecraft ion engines

6 — Cs Cesium 55: soft metal, melts on a hot day, reactive, largest stable atoms; atomic clocks, global navigation (GPS), vacuum tube scavenger; Ba Barium 56: soft metal, absorbs X-rays; stomach X-ray contrast enhancer, green firworks, whitener and filler for paper, plastic, and rubber; 57 - 71 Rare Earth Metals; Hf Hafnium 72: non-corroding metal, absorbs neutrons; nuclear reactor control rods in submarines, plasma torch electrodes; Ta Tantalum 73: high-melting-point non-corroding metal; labware, surgical tools, artificial joints, capacitors, mobile phones; W Tungsten 74: highest-melting-point metal, dense; filaments in lamps and TVs, cutting tools, abrasives, thermocouples; Re Rhenium 75: high-melting-point dense metal; rocket engines, heater coils, lab filaments, electric contacts, thermocouples, catalyst; Os Osmium 76: non-corroding high-melting-point hard metal, densest element (same as iridium); electric contacts, pen tips, needles, fingerprint powder; Ir Iridium 77: non-corroding hard metal, densest element (same as osmium); labware, spark plugs, pen tips, needles; Pt Platinum 78: non-corroding dense metal; labware, spark plugs, catalyst, pollution control, petroleum cracking, processing fats; Au Gold 79: most malleable element, dense non-tarnishing colored metal; jewelry, coins, ultra-thin gold leaf, electric contacts; Hg Mercury 80: liquid metal, toxic; thermometers, barometers, thermostats, street lamps, fluorescent lamps, dentistry; Tl Thallium 81: soft metal, toxic; low-melting-point mercury alloys, low-temperature thermometers, undersea lamps, photocells; Pb Lead 82: dense, soft, non-corroding metal, toxic; weights, solders, batteries, bullets, crystal glass, old plumbing, radiation shield; Bi Bismuth 83: low-melting-point brittle metal; solders, fuses, fire sprinklers (plugs melt when hot), cosmetics pigment; Po Polonium 84: radioactive, long-lived; first radioactive element found, small traces in nature, anti-static brushes, tobacco; At Astatine 85: radioactive, short-lived; small traces in nature, cancer medicine; Rn Radon 86: radioactive gas, short-lived; environmental hazard, surgical implants for cancer treatment

7 — Fr Francium 87: radioactive, short-lived atoms larger than cesium; small traces in nature, studied in laser atom traps; Ra Radium 88: radioactive, long-lived; luminous watches (now banned), medical radon production, radiography, radwaste; 89 - 103 Actinide Metals; Rf Rutherfordium 104; Db Dubnium 105; Sg Seaborgium 106; Bh Bohrium 107; Hs Hassium 108; Mt Meitnerium 109; Ds Darmstadtium 110; Rg Roentgenium 111; Cn Copernicium 112; Nh Nihonium 113; Fl Flerovium 114; Mc Moscovium 115; Lv Livermorium 116; Ts Tennessine 117; Og Oganesson 118

Superheavy Elements — radioactive, short-lived; never found in nature, no uses except atomic research

8 — 119; 120; 121...

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.

Metalloids are partly like metals and partly like nonmetals. 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.

Atoms

Nucleus of protons and neutrons; Electron shells

Particles: +1 Proton; 0 Neutron; -1 Electron

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.

Salt (Na^+ Cl^-) — **Ionic bond**: One atom takes an electron from another atom and the oppositely charged ions attract.

Water (H_2O) — **Covalent bond**: Atoms share their outer electrons.

Silver (Ag) — **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.

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.

Rare Earth Metals: La Lanthanum 57: soft metal; optical glass, telescope eyepieces, camera lenses, lighter flints, arc lamps; Ce Cerium 58: soft metal; most abundant rare earth metal, lighter flints, gas lamp mantles, self-cleaning ovens, glass polishing; Pr Praseodymium 59: soft metal; torchworkers' didymium eyeglasses (Pr-Nd), lighter flints, arc lamps, magnets, yellow glass; Nd Neodymium 60: soft metal; strong magnets (Nd-Fe-B), electric motors, speakers and headphones, lasers, lighter flints; Pm Promethium 61: radioactive, long-lived; human-made, small traces in nature, luminous dials, sheet thickness gauges; Sm Samarium 62: soft metal; magnets (Sm-Co), electric motors, speakers and headphones, infrared sensors, infrared-absorbing glass; Eu Europium 63: soft metal; phosphors in color TVs and trichromatic lamps, luminous paint, lasers; Gd Gadolinium 64: soft metal, best neutron absorber, magnetic; magnetic resonance imaging (MRI) contrast enhancer, phosphors, neutron radiography; Tb Terbium 65: soft metal; phosphors in color TVs and trichromatic lamps, computer disks, magnetostrictive smart materials (Terfenol-D®); Dy Dysprosium 66: soft metal; nuclear control rods, MRI phosphors, computer disks, magnetostrictive smart materials (Terfenol-D®); Ho Holmium 67: soft metal; infrared lasers, laser surgery, eye-safe laser rangefinders, computer disks, yellow glass filters; Er Erbium 68: soft metal; fiber optic signal amplifiers, infrared lasers, laser surgery, pink glass, sunglasses, vanadium alloys; Tm Thulium 69: soft metal; rarest stable rare earth metal, infrared lasers, laser surgery, phosphors; Yb Ytterbium 70: soft metal; fiber optic signal amplifiers, infrared fiber lasers, stainless steel alloys; Lu Lutetium 71: soft metal, densest and hardest rare earth metal; cancer-fighting photodynamic (light-activated) medicine

Actinide Metals: Ac Actinium 89: radioactive, long-lived; small traces in nature, cancer medicine, neutron source, radwaste; Th Thorium 90: radioactive, long-lived; most abundant radioactive element, nuclear reactor fuel, gas lamp mantles, tungsten filaments; Pa Protactinium 91: radioactive, long-lived; small traces in nature, no uses, radwaste; U Uranium 92: radioactive, long-lived, dense; nuclear reactor fuel, nuclear weapons, counterweights, armor piercing bullets; Np Neptunium 93: radioactive, long-lived; small traces in nature, neutron detectors, dosimeters, nuclear weapons, radwaste; Pu Plutonium 94: radioactive, long-lived; small traces in nature, nuclear reactor fuel, spacecraft power, nuclear weapons; Am Americium 95: radioactive, long-lived; never found in nature, smoke detectors, sheet thickness gauges, radwaste; Cm Curium 96: radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste; Bk Berkelium 97: radioactive, long-lived; never found in nature, no uses, radwaste; Cf Californium 98: radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste; Es 99 Einsteinium; Fm 100 Fermium; Md 101 Mendelevium; No 102 Nobelium; Lr 103 Lawrencium

radioactive, short-lived; never found in nature, no uses except atomic research