

The Periodic Table of the Elements, in Pictures

Periods	Alkali Metals Group 1	Alkali Earth Metals Group 2	Transition Metals										Boron Group 13	Carbon Group 14	Nitrogen Group 15	Oxygen Group 16	Halogens Group 17	Noble Gases Group 18																																																																		
1	H Hydrogen Sun and Stars	He Helium Balloons											B Boron Sports Equipment	C Carbon Basis of Life's Molecules	N Nitrogen Protein	O Oxygen Air	F Fluorine Toothpaste	Ne Neon Advertising Signs																																																																		
2	Li Lithium Batteries	Be Beryllium Emeralds											Al Aluminum Airplanes	Si Silicon Stone, Sand, and Soil	P Phosphorus Bones	S Sulfur Egg Yolks	Cl Chlorine Swimming Pools	Ar Argon Light Bulbs																																																																		
3	Na Sodium Salt	Mg Magnesium Chlorophyll											K Potassium Fruits and Vegetables	Ca Calcium Shells and Bones	Sc Scandium Bicycles	Ti Titanium Aerospace	V Vanadium Springs	Cr Chromium Stainless Steel	Mn Manganese Earthmovers	Fe Iron Steel Structures	Co Cobalt Magnets	Ni Nickel Coins	Cu Copper Electric Wires	Zn Zinc Brass Instruments	Ga Gallium Light-Emitting Diodes (LEDs)	Ge Germanium Semiconductor Electronics	As Arsenic Poison	Se Selenium Copiers	Br Bromine Photography Film	Kr Krypton Flashlights																																																						
4	Rb Rubidium Global Navigation	Sr Strontium Fireworks	Y Yttrium Lasers	Zr Zirconium Chemical Pipelines	Nb Niobium Mag Lev Trains	Mo Molybdenum Cutting Tools	Tc Technetium Radioactive Diagnosis	Ru Ruthenium Electric Switches	Rh Rhodium Searchlight Reflectors	Pd Palladium Pollution Control	Ag Silver Jewelry	Cd Cadmium Paint	In Indium Liquid Crystal Displays (LCDs)	Sn Tin Plated Food Cans	Sb Antimony Car Batteries	Te Tellurium Thermoelectric Coolers	I Iodine Disinfectant	Xe Xenon High-Intensity Lamps																																																																		
5	Cs Cesium Atomic Clocks	Ba Barium X-Ray Diagnosis	Rare Earth Metals		Hf Hafnium Nuclear Submarines	Ta Tantalum Mobile Phones	W Tungsten Lamp Filaments	Re Rhenium Rocket Engines	Os Osmium Pen Points	Ir Iridium Spark Plugs	Pt Platinum Labware	Au Gold Jewelry	Hg Mercury Thermometers	Tl Thallium Low-Temperature Thermometers	Pb Lead Weights	Bi Bismuth Fire Sprinklers	Po Polonium Anti-Static Brushes	At Astatine Radioactive Medicine	Rn Radon Surgical Implants																																																																	
6	Fr Francium Laser Atom Traps	Ra Radium Luminous Watches	Actinide Metals		Rf Rutherfordium	Db Dubnium	Sg Seaborgium	Bh Bohrium	Hs Hassium	Mt Meitnerium	Ds Darmstadtium	Rg Roentgenium	Superheavy Elements radioactive, never found in nature, no uses except atomic research																																																																							
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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.

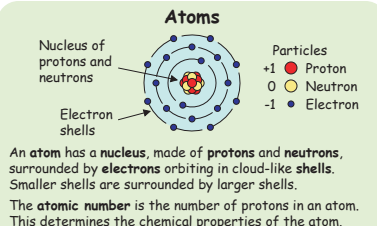
Periods

Group 1

H Hydrogen 1
lightest element; 90% of atoms in the universe, sun and stars, water (H₂O), life's organic molecules

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.

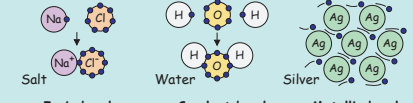
Alkali Earth Metals are reactive and readily form compounds but are not found free in nature. Their oxides are called **alkali earths**. In pure form, they are soft and somewhat brittle metals.



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	3	4	5	6	7	8	0
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.

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.

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.

13	14	15	16	17	18													
B Boron 5 hard black solid; borax soap, 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, DNA, ammonia, fertilizer, explosives (TNT), refrigerants	O Oxygen 8 colorless gas; 21% of air, H ₂ O, 65% of the body, organic molecules, blood, breathing, fire's half of earth's crust, minerals, oxides	F Fluorine 9 yellowish poisonous gas, most reactive element; glowing fluoride, toothpaste, nonstick cookware, CFC refrigerants	Ne Neon 10 inert gas; second lightest element; fuel for nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant													
Al Aluminum 13 lightweight metal; corroding metal; kitchenware, cans, foil, machinery, cars, planes, bikes, feldspar, granite, clay, ceramics, corundum, gems	Si Silicon 14 hard metalloids; 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, egg yolks, onions, garlic, skunks, hot springs, volcanos, gypsum, rubber, acids, papermaking	Cl Chlorine 17 greenish poisonous 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													
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, rock crushers, rail, tools, 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	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 metalloids; semiconductors, transistors, rectifiers, diodes, photocells, lenses, infrared windows	As Arsenic 33 brittle metalloids; poisons, semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, tiny lasers	Se Selenium 34 brittle gray solid; photocopyers, laser printers, photo cells, 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	
Rb Rubidium 37 soft metal, reactive; atomic clocks, global navigation (GPS), vacuum tube scavenger	Sr Strontium 38 soft metal; red fireworks, flares, phosphors, nuclear reactors, 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; hard steel, cutting tools, drill bits, armor plate, gun barrels, fertilizer	Mo Molybdenum 42 high-melting-point metal; hard steel, cutting tools, 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 metalloids; solders, lead hardener, batteries, bullets, semiconductors, photocells, matches, flame retardant	Te Tellurium 52 brittle metalloids; alloys, semiconductors, 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	
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 fireworks, whitener and filler for paper, plastic, and rubber	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, 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 in nature, 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
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	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	112	113	114	115	116	117	118

Superheavy Elements

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

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".