The Periodic Table of the Elements, in Pictures

Periods

Alkali Metals Group 1

Alkali Earth Metals 2

Transition Metals 3 4 5 6 7 8 9 10 11 12

Boron Group 13

Carbon Group 14

Nitrogen Group 15

Oxygen Group 16

Halogens 17

Noble Gases 18

1 H Hydrogen — Sun and Stars
2 He Helium — Balloons

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

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

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

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

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

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

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

8 119 120 121...

Rare Earth Metals

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

Actinide Metals

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

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Atomic Symbol
Atomic Number — number of protons
Symbols
A ☐○ Z
_____ium
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

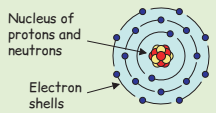
The Periodic Table of the Elements, in Words

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.

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.

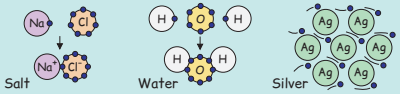
Protons have positive **electric charge**, neutrons are neutral, and electrons are negative. Normally, an atom has equal numbers of protons and electrons. An **ion** is a charged atom with more or fewer electrons than protons.

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.

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.

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).

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 explosive gas, lightest element; 90% of atoms in the universe, sun and stars, water (H_2O), life's organic molecules																	He Helium 2 inert gas, second lightest element; nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant
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 fireworks, 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 104 Rutherfordium	Db 105 Dubnium	Sg 106 Seaborgium	Bh 107 Bohrium	Hs 108 Hassium	Mt 109 Meitnerium	Ds 110 Darmstadtium	Rg 111 Roentgenium	Cn 112 Copernicium	Nh 113 Nihonium	Fl 114 Flerovium	Mc 115 Moscovium	Lv 116 Livermorium	Ts 117 Tennessine	Og 118 Oganesson
8	119	120	121...															

Superheavy Elements

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

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 eye-glasses (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

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.