

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 1	He Helium 2											B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9	Ne Neon 10												
2	Li Lithium 3	Be Beryllium 4											Al Aluminum 13	Si Silicon 14	P Phosphorus 15	S Sulfur 16	Cl Chlorine 17	Ar Argon 18												
3	Na Sodium 11	Mg Magnesium 12											K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31	Ge Germanium 32	As Arsenic 33	Se Selenium 34	Br Bromine 35	Kr Krypton 36
4	Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49	Sn Tin 50	Sb Antimony 51	Te Tellurium 52	I Iodine 53	Xe Xenon 54												
5	Cs Cesium 55	Ba Barium 56	Rare Earth Metals										Tl Thallium 81	Pb Lead 82	Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86												
6	Fr Francium 87	Ra Radium 88	Actinide Metals										Nh Nihonium 113	Fl Flerovium 114	Mc Moscovium 115	Lv Livermorium 116	Ts Tennessine 117	Og Oganesson 118												
7	Superheavy Elements																													
8	radioactive, never found in nature, no uses except atomic research																													

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.

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.

The Periodic Table of the Elements, in Words

Periods	Group 1	Group 2	Transition Metals										Group 13	Group 14	Group 15	Group 16	Group 17	Group 18												
1	H Hydrogen 1	He Helium 2											B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9	Ne Neon 10												
2	Li Lithium 3	Be Beryllium 4											Al Aluminum 13	Si Silicon 14	P Phosphorus 15	S Sulfur 16	Cl Chlorine 17	Ar Argon 18												
3	Na Sodium 11	Mg Magnesium 12											K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31	Ge Germanium 32	As Arsenic 33	Se Selenium 34	Br Bromine 35	Kr Krypton 36
4	Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49	Sn Tin 50	Sb Antimony 51	Te Tellurium 52	I Iodine 53	Xe Xenon 54												
5	Cs Cesium 55	Ba Barium 56	Rare Earth Metals										Tl Thallium 81	Pb Lead 82	Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86												
6	Fr Francium 87	Ra Radium 88	Actinide Metals										Nh Nihonium 113	Fl Flerovium 114	Mc Moscovium 115	Lv Livermorium 116	Ts Tennessine 117	Og Oganesson 118												
7	Superheavy Elements																													
8	radioactive, short-lived; never found in nature, no uses except atomic research																													

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	3	4	5	6	7	8	8
Valence number**	+1	+2	+2	+3	+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 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.

Group 13	Group 14	Group 15	Group 16	Group 17	Group 18												
B Boron 5 hard black solid; borax soap, fertilizer, stiff fibers, sports equipment, borosilicate glass, semiconductors	C Carbon 6 hard diamond, soft graphite; basis of life's organic molecules, DNA, ammonia, CO ₂ wood, paper, cloth, plastic, coal, oil, gasoline	N Nitrogen 7 colorless gas; 78% of air, organic molecules, protein, muscles, blood, breathing, fire, half of explosives (TNT), refrigerants	O Oxygen 8 brilliant yellow solid; 21% of air, H ₂ O, 65% of the body, organic molecules, blood, breathing, fire, 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; nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant												
Al Aluminum 13 lightweight non-corroding metal; 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 brilliant yellow solid; brittle gray solid; photocopyers, laser printers, photo film, flame retardant, leaded gasoline, sedatives	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, cement, gunpowder	Ca Calcium 20 soft metal; bones, teeth, milk, furace bricks, aquamarines	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, aircraft, white paint, blue sapphires	V Vanadium 23 hard metal; hard strong resilient steel, structures, vehicles, springs, drive shafts, tools, white point, blue sapphires	Cr Chromium 24 hard shiny metal; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, car trim, paints, recording tape, emeralds & rubies												
Rb Rubidium 37 reactive; atomic clocks, global navigation (GPS), vacuum tube scavenger	Sr Strontium 38 red fireworks, phosphors, nuclear batteries, medical diagnostic tracer, nuclear fallout	Y Yttrium 39 high-melting-point metal; phosphors in color TVs, lasers (YAG, YLF), furnace bricks, high-temperature superconductors	Zr Zirconium 40 non-corroding metal; nuclear reactor control rods in submarines, plasma torch electrodes	Nb Niobium 41 high-melting-point non-corroding metal; chemical pipelines, superconductors, magnetic levitation trains, MRI magnets	Mo Molybdenum 42 high-melting-point metal; dense; filaments in lamps and TVs, cutting tools, abrasives, thermocouples												
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; contrast enhancer; green fireworks, whitener and filler for paper, plastic, and rubber	Rare Earth Metals										Tl Thallium 81 dense, soft, non-corroding 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, fire sprinklers (plugs melt when hot), cosmetics pigment	Bi Bismuth 83 brittle metalloid; solders, lead hardener, batteries, bullets, semiconductors, photocells, matches, flame retardant	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										Nh Nihonium 113 radioactive, short-lived; never found in nature, no uses, radwaste	Fl Flerovium 114 radioactive, short-lived; never found in nature, no uses, radwaste	Mc Moscovium 115 radioactive, short-lived; never found in nature, no uses, radwaste	Lv Livermorium 116 radioactive, short-lived; never found in nature, no uses, radwaste	Ts Tennessine 117 radioactive, short-lived; never found in nature, no uses, radwaste	Og Oganesson 118 radioactive, short-lived; never found in nature, no uses, radwaste
radioactive, short-lived; never found in nature, no uses except atomic research																	