

# 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		2		3		4		5		6		7		8		9	
1	H Hydrogen Sun and Stars		He Helium Balloons		Li Lithium Batteries		Be Beryllium Emeralds		B Boron Sports Equipment		C Carbon Basis of Life's Molecules		N Nitrogen Protein		O Oxygen Air		F Fluorine Toothpaste	
2	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	
3	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	
4	Cs Cesium Atomic Clocks		Ba Barium X-Ray Diagnosis		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	
5	Fr Francium Laser Atom Traps		Ra Radium Luminous Watches		Ac Actinium Radioactive Medicine		Th Thorium Gas Lamp Mantles		Pa Protactinium Radioactive Waste		U Uranium Nuclear Power		Np Neptunium Radioactive Waste		Pu Plutonium Nuclear Weapons		Am Americium Smoke Detectors	
6	La Lanthanum Telescope Lenses		Ce Cerium Lighter Flints		Pr Praseodymium Torchworkers' Eyeglasses		Nd Neodymium Electric Motor Magnets		Pm Promethium Luminous Dials		Sm Samarium Electric Motor Magnets		Eu Europium Color Televisions		Gd Gadolinium MRI Diagnosis		Tb Terbium Fluorescent Lamps	
7	Dy Dysprosium Smart Material Actuators		Ho Holmium Laser Surgery		Er Erbium Optical Fiber Communications		Tm Thulium Laser Surgery		Yb Ytterbium Scientific Fiber Lasers		Lu Lutetium Photodynamic Medicine		Ac Actinium Radioactive Medicine		Th Thorium Gas Lamp Mantles		Pa Protactinium Radioactive Waste	
8	Es Einsteinium radioactive, never found in nature, no uses except atomic research		Fm Fermium radioactive, never found in nature, no uses except atomic research		Md Mendelevium radioactive, never found in nature, no uses except atomic research		No Nobelium radioactive, never found in nature, no uses except atomic research		Lr Lawrencium radioactive, never found in nature, no uses except atomic research									

# 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.

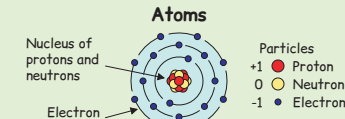
## Group 1

**H Hydrogen** 1  
lightest element; 90% of atoms in the universe, sun and stars, water (H<sub>2</sub>O), 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

**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.

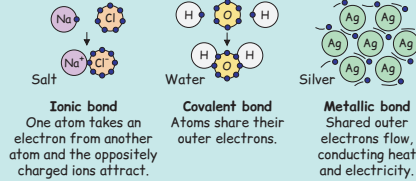


An atom has a nucleus, made of protons and neutrons, surrounded by electrons orbiting in cloud-like shells. Smaller shells are surrounded by larger shells.

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.



## 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.

**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.

**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).

## 18

**He Helium** 2  
inert gas, second lightest element; nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant

1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
H Hydrogen 1 lightest element; 90% of atoms in the universe, sun and stars, water (H <sub>2</sub> O), life's organic molecules		He Helium 2 inert gas, second lightest element; nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant																																	
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 <sub>2</sub> 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 <sub>2</sub> 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; orange-red neon tubes for advertising signs, lasers, supercold refrigerant																					
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 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, eggs, onions, garlic, skunks, hot springs, volcanoes, 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, 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, nickel 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 film, flame retardant, leaded gasoline, sedatives		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 metal; chemical pipelines, nuclear reactors, furnace bricks, abrasives, zircon gems		Nb Niobium 41 high-melting-point non-corroding metal; chemical pipelines, superconductors, 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, jewelry, silverware, coins, dentistry, photo film		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, nickel batteries, lead 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, whiteners 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	
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	

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

## 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.