

# 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.

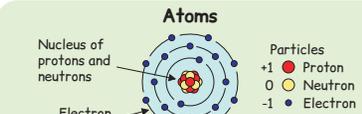
Periods

## Group 1

**H Hydrogen** 1  
lightest element; 90% of atoms in the universe, sun and stars, water (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** 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.



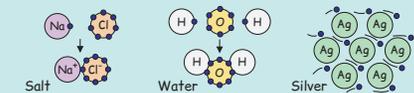
An atom has a nucleus, made of protons and neutrons, surrounded by electrons orbiting in cloud-like shells. Smaller shells are surrounded by larger shells.

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.

## 18

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

**Ne Neon** 10  
inert gas; orange-red neon tubes for advertising signs, lasers, supercold refrigerant

**Ar Argon** 18  
inert gas; 1% of air, most abundant inert gas, light bulbs, "neon" tubes, lasers, welding gas

**Krypton** 36  
inert gas; high-intensity lamps, headlights, flashlights, lanterns, "neon" tubes, lasers

**Xenon** 54  
inert gas; high-intensity lamps, headlights, stadium lamps, projectors, strobes, lasers, spacecraft ion engines

**Rn Radon** 86  
radioactive gas; short-lived; environmental hazard, surgical implants for cancer treatment

## 2

**Li Lithium** 3  
lightest metal; soft, reactive; lightweight aluminum alloys, batteries, impact-resistant ceramic cookware, mood stabilizer

## 3

**Be Beryllium** 4  
lightweight metal; non-sparking copper alloy tools, aerospace, X-ray windows, beryl gems; emeralds and aquamarines

## 11

**Na Sodium** 11  
soft metal, reactive; salt (NaCl), nerves, baking soda, antacids, lye, soap, soda ash, glass, papermaking, street lamps

## 12

**Mg Magnesium** 12  
lightweight metal; chlorophyll in green plants, talc, basalt, aluminum alloys, cars, planes, bikes, flares, sparklers, antacids

## 19

**K Potassium** 19  
soft metal, reactive; salts, nerves, nutrients in fruits and vegetables, soap, fertilizer, potash, matches, gunpowder

## 20

**Ca Calcium** 20  
soft metal; bones, teeth, milk, leaves, vegetables, shells, coral, limestone, chalk, gypsum, plaster, mortar, cement, marble, antacids

## 21

**Sc Scandium** 21  
soft lightweight metal; aluminum alloys, racing bikes, stadium lamps, furnace bricks, aquamarines

## 22

**Ti Titanium** 22  
strongest lightweight metal; heat-resistant; aerospace, racing bikes, artificial joints, white paint, blue sapphires

## 23

**V Vanadium** 23  
hard metal; hard strong resilient steel, structures, vehicles, springs, driveshafts, tools, aerospace, violet sapphires

## 24

**Cr Chromium** 24  
hard shiny metal; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, car trim, paints, recording tape, emeralds & rubies

## 25

**Mn Manganese** 25  
hard metal; hard tough steel, rock crushers, rail wheels, axes, batteries, fertilizer, amethysts

## 26

**Fe Iron** 26  
medium-hard metal, magnetic; steel alloys are mostly iron, structures, vehicles, magnets, Earth's core, red rocks, blood

## 27

**Co Cobalt** 27  
hard metal, magnetic; hard strong steel, cutting tools, turbines, magnets (Al-Ni-Co), blue glass, ceramics, vitamin B-12

## 28

**Ni Nickel** 28  
medium-hard metal, magnetic; stainless steel (Fe-Cr-Ni), kitchenware, nichrome heaters, nickel batteries, coins, Earth's core

## 29

**Cu Copper** 29  
colored metal, conducts heat and electricity well; wires, cookware, brass (Cu-Zn), bronze (Cu-Sn), coins, pipes, blue crab blood

## 30

**Zn Zinc** 30  
non-corroding metal; galvanized steel, brass (Cu-Zn), batteries, white paint, phosphors in TVs and lamps, fertilizer

## 31

**Ga Gallium** 31  
soft metal, melts on a hot day; semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, fry lasers

## 32

**Ge Germanium** 32  
brittle metalloid; semiconductors, transistors, rectifiers, diodes, lenses, infrared windows

## 33

**As Arsenic** 33  
brittle metalloid; poisons, semiconductors, light-emitting diodes (LEDs) (GaAs), signal lights, finy lasers

## 34

**Se Selenium** 34  
brittle gray solid; photocopyers, laser printers, photo cells, red glass, dandruff shampoo, rubber

## 37

**Rb Rubidium** 37  
soft metal, reactive; atomic clocks, global navigation (GPS), vacuum tube scavenger

## 38

**Sr Strontium** 38  
soft metal; red fireworks, flares, phosphors, nuclear batteries, medical diagnostic tracer, nuclear fallout

## 39

**Y Yttrium** 39  
soft metal; phosphors in color TVs, lasers (YAG, YLF), furnace bricks, high-temperature superconductors

## 40

**Zr Zirconium** 40  
non-corroding neutron-resistant metal; chemical pipelines, nuclear reactors, furnace bricks, abrasives, zircon gems

## 41

**Nb Niobium** 41  
high-melting-point non-corroding metal; chemical pipelines, superconductors, magnetic levitation trains, MRI magnets

## 42

**Mo Molybdenum** 42  
high-melting-point metal; hard steel, cutting tools, drill bits, armor plate, gun barrels, fertilizer

## 43

**Tc Technetium** 43  
radioactive, long-lived; first human-made element, only traces on Earth, found in stars, medical diagnostic tracer

## 44

**Ru Ruthenium** 44  
non-corroding hard metal; electric contacts, leaf switches, pen tips, catalyst, hydrogen production

## 45

**Rh Rhodium** 45  
non-corroding hard shiny metal; labware, reflectors, electric contacts, thermocouples, catalyst, pollution control

## 46

**Pd Palladium** 46  
non-corroding hard metal; absorbs hydrogen; labware, electric contacts, dentistry, catalyst, pollution control

## 47

**Ag Silver** 47  
soft shiny metal, conducts electricity best of all elements; jewelry, silverware, coins, dentistry, photo film

## 48

**Cd Cadmium** 48  
non-corroding soft metal, toxic; electroplated steel, nickel batteries, red and yellow paints, fire sprinklers

## 49

**In Indium** 49  
soft metal; solders, glass seals, glass coatings, liquid crystals (LCDs), semiconductors, diodes, photocells

## 50

**Sn Tin** 50  
non-corroding soft metal; solders, plated food cans, bronze (Cu-Sn), pewter cups, glassmaking, fire sprinklers

## 51

**Sb Antimony** 51  
brittle metalloid; solders, lead hardener, batteries, bullets, semiconductors, photocells, matches, flame retardant

## 52

**Te Tellurium** 52  
brittle metalloid; alloys, semiconductors, computer disks, thermo-electric coolers and generators

## 55

**Cs Cesium** 55  
soft metal, melts on a hot day, reactive, largest stable atoms; atomic clocks, global navigation (GPS), vacuum tube scavenger

## 56

**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**

## 72

**Hf Hafnium** 72  
non-corroding metal; absorbs neutrons; nuclear reactor control rods in submarines, plasma torch electrodes

## 73

**Ta Tantalum** 73  
high-melting-point non-corroding metal; labware, surgical tools, artificial joints, capacitors, mobile phones

## 74

**W Tungsten** 74  
highest-melting-point metal, dense; filaments in lamps and TVs, cutting tools, abrasives, thermocouples

## 75

**Re Rhenium** 75  
high-melting-point dense metal; rocket engines, heater coils, lab filaments, electric contacts, thermocouples, catalyst

## 76

**Os Osmium** 76  
non-corroding high-melting-point hard metal; densest element (same as iridium); labware, spark plugs, pen tips, needles, fingerprint powder

## 77

**Ir Iridium** 77  
non-corroding hard metal, densest element (same as osmium); labware, spark plugs, pen tips, needles

## 78

**Pt Platinum** 78  
non-corroding dense metal; labware, spark plugs, catalyst, pollution control, petroleum cracking, processing fats

## 79

**Au Gold** 79  
most malleable element, dense non-tarnishing colored metal; jewelry, coins, ultra-thin gold leaf, electric contacts

## 80

**Hg Mercury** 80  
liquid metal, toxic; thermometers, barometers, thermostats, street lamps, fluorescent lamps, dentistry

## 81

**Tl Thallium** 81  
soft metal, toxic; low-melting-point mercury alloys, low-temperature thermometers, undersea lamps, photocells

## 82

**Pb Lead** 82  
dense, soft, non-corroding metal, toxic; weights, solders, batteries, bullets, crystal glass, old plumbing, radiation shield

## 83

**Bi Bismuth** 83  
low-melting-point brittle metal; solders, fuses, fire sprinklers (plugs melt when hot), cosmetics pigment

## 84

**Po Polonium** 84  
radioactive, long-lived; first radioactive element found, small traces in nature, anti-static brushes, tobacco

## 87

**Fr Francium** 87  
radioactive, short-lived; atoms larger than cesium; small traces in nature, studied in laser atom traps

## 88

**Ra Radium** 88  
radioactive, long-lived; luminous watches (now banned), medical radon production, radiography, radwaste

**89 - 103**  
**Actinide Metals**

## 104

**Rf Rutherfordium** 104

## 105

**Db Dubnium** 105

## 106

**Sg Seaborgium** 106

## 107

**Bh Bohrium** 107

## 108

**Hs Hassium** 108

## 109

**Mt Meitnerium** 109

## 110

**Ds Darmstadtium** 110

## 111

**Cn Copernicium** 111

## 112

**Nh Nihonium** 112

## 113

**Fl Flerovium** 113

## 114

**Mc Moscovium** 114

## 115

**Lv Livermorium** 115

## 116

**Ts Tennessine** 116

## 117

**Og Oganesson** 117

**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.

## Superheavy Elements

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

<b>La Lanthanum</b> 57 soft metal; optical glass, telescope eyepieces, camera lenses, laser flint, arc lamps	<b>Ce Cerium</b> 58 soft metal; most abundant rare earth metal, lighter flints, gas lamp mantles, self-cleaning ovens, glass polishing	<b>Pr Praseodymium</b> 59 soft metal; torchworkers' didymium eye-glasses (Pr-Nd), arc lamps, magnets, yellow glass	<b>Nd Neodymium</b> 60 soft metal; strong magnets (Nd-Fe-B), electric motors, speakers and headphones, lasers, lighter flints	<b>Pm Promethium</b> 61 radioactive, long-lived; human-made, small traces in nature, luminous dials, sheet thickness gauges	<b>Sm Samarium</b> 62 soft metal; magnets (Sm-Co), electric motors, speakers and headphones, infrared sensors, infrared-absorbing glass	<b>Eu Europium</b> 63 soft metal; phosphors in color TVs and trichromatic lamps, luminous paint, lasers	<b>Gd Gadolinium</b> 64 soft metal, best neutron absorber, magnetic resonance imaging (MRI) contrast enhancer, phosphors, neutron radiography	<b>Tb Terbium</b> 65 soft metal; phosphors in color TVs and computer disks, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)	<b>Dy Dysprosium</b> 66 soft metal; nuclear control rods, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)	<b>Ho Holmium</b> 67 soft metal; infrared lasers, laser surgery, eye-safe laser rangefinders, computer disks, yellow glass filters	<b>Er Erbium</b> 68 soft metal; fiber optic signal amplifiers, infrared lasers, laser surgery, pink glass, sunglasses, vanadium alloys	<b>Tm Thulium</b> 69 soft metal; rare earth metal, infrared lasers, laser surgery, phosphors	<b>Yb Ytterbium</b> 70 soft metal; fiber optic signal amplifiers, fiber lasers, stainless steel alloys	<b>Lu Lutetium</b> 71 soft metal, densest and hardest rare earth metal; cancer-fighting photodynamic (light-activated) medicine
<b>Ac Actinium</b> 89 radioactive, long-lived; small traces in nature, cancer medicine, neutron source, radwaste	<b>Th Thorium</b> 90 radioactive, long-lived; most abundant radioactive element, nuclear reactor fuel, gas lamp mantles, tungsten filaments	<b>Pa Protactinium</b> 91 radioactive, long-lived; small traces in nature, no uses, radwaste	<b>U Uranium</b> 92 radioactive, long-lived, dense; nuclear reactor fuel, nuclear weapons, counterweights, armor piercing bullets	<b>Np Neptunium</b> 93 radioactive, long-lived; small traces in nature, neutron detectors, dosimeters, nuclear weapons, radwaste	<b>Pu Plutonium</b> 94 radioactive, long-lived; small traces in nature, nuclear reactor fuel, spacecraft power, nuclear weapons	<b>Am Americium</b> 95 radioactive, long-lived; never found in nature, smoke detectors, sheet thickness gauges, radwaste	<b>Cm Curium</b> 96 radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste	<b>Bk Berkelium</b> 97 radioactive, long-lived; never found in nature, no uses, radwaste	<b>Cf Californium</b> 98 radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste	<b>Es Einsteinium</b> 99 radioactive, short-lived; never found in nature, no uses except atomic research	<b>Fm Fermium</b> 100	<b>Md Mendeleevium</b> 101	<b>No Nobelium</b> 102	<b>Lr Lawrencium</b> 103