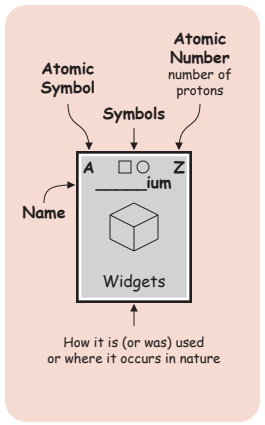
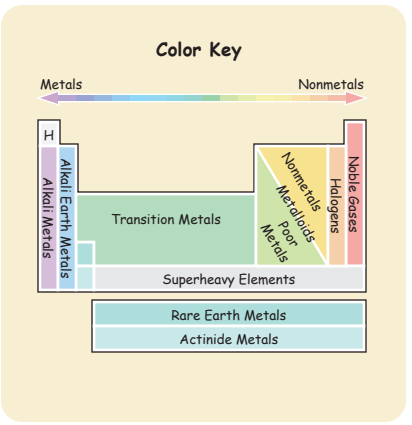


The Periodic Table of the Elements, in Pictures

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	He Helium											B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon																														
2	Li Lithium	Be Beryllium											Al Aluminum	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine	Ar Argon																														
3	Na Sodium	Mg Magnesium											K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton																		
4	Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon																														
5	Cs Cesium	Ba Barium											Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon																											
6	Fr Francium	Ra Radium											Superheavy Elements																																			
7	radioactive, never found in nature, no uses except atomic research																																															
8	radioactive, never found in nature, no uses except atomic research																																															
	<table border="1"> <tr> <td>La Lanthanum</td> <td>Ce Cerium</td> <td>Pr Praseodymium</td> <td>Nd Neodymium</td> <td>Pm Promethium</td> <td>Sm Samarium</td> <td>Eu Europium</td> <td>Gd Gadolinium</td> <td>Tb Terbium</td> <td>Dy Dysprosium</td> <td>Ho Holmium</td> <td>Er Erbium</td> <td>Tm Thulium</td> <td>Yb Ytterbium</td> <td>Lu Lutetium</td> </tr> <tr> <td>Ac Actinium</td> <td>Th Thorium</td> <td>Pa Protactinium</td> <td>U Uranium</td> <td>Np Neptunium</td> <td>Pu Plutonium</td> <td>Am Americium</td> <td>Cm Curium</td> <td>Bk Berkelium</td> <td>Cf Californium</td> <td>Es Einsteinium</td> <td>Fm Fermium</td> <td>Md Mendeleevium</td> <td>No Nobelium</td> <td>Lr Lawrencium</td> </tr> </table>																		La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium	Ac Actinium	Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium	Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium	Fm Fermium	Md Mendeleevium	No Nobelium	Lr Lawrencium
La Lanthanum	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium																																		
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- Solid** (square icon)
 - Liquid** (teardrop icon)
 - Gas** (cloud icon)
 - Human Body** (person icon)
 - Earth's Crust** (globe icon)
 - Magnetic** (magnet icon)
 - Noble Metals** (crown icon)
 - Radioactive** (radiation icon)
 - Only Traces Found in Nature** (lightning bolt icon)
 - Never Found in Nature** (X icon)
- The color of the symbol is the color of the element in its most common pure form.
 Examples: ■ metallic solid, ● red liquid, ☁ colorless gas



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.

Group 2

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.

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

Na Sodium 11
soft metal, reactive; salt (NaCl), nerves, baking soda, antacids, eye 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

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

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

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

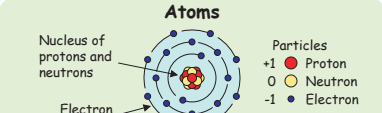
Fr Francium 87
radioactive, short-lived; atoms larger than cesium; small traces in nature, studied in laser atom traps

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

Groups 3-10

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.



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.

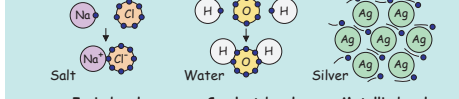
Protons have positive electric charge, neutrons are neutral, and electrons are negative. Normally, an atom has equal numbers of protons and electrons. An ion is a charged atom with more or fewer electrons than protons.

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	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.

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).

18
He Helium 2
inert gas, second lightest element; fuel for nuclear fusion in sun and stars, balloons, lasers, supercold refrigerant

13 **B Boron** 5
hard black solid; borax soap, fertilizer, stiff fibers, sports equipment, heat-resistant borosilicate glass, semiconductors

14 **C Carbon** 6
hard diamond, soft graphite; basis of life's organic molecules, animals, plants, CO₂ wood, paper, cloth, plastic, coal, oil, gasoline

15 **N Nitrogen** 7
colorless gas; 78% of air; organic molecules, protein, muscles, DNA, ammonia, fertilizer, explosives (TNT), refrigerants

16 **O Oxygen** 8
colorless gas; 21% of air, H₂O, 65% of the body; organic molecules, blood, breathing, fire, half of Earth's crust, minerals, oxides

17 **F Fluorine** 9
yellowish poisonous gas, most reactive element; glowing fluoride, toothpaste, nonstick cookware, CFC refrigerants

13 **Al Aluminum** 13
lightweight metal; corroding metal; kitchenware, cans, foil, machinery, cars, planes, bikes, feldspar, granite, clay, ceramics, corundum, gems

14 **Si Silicon** 14
hard metalloids; quartz, granite, sand, soil, clay, ceramics, glass, algae, diatoms, semiconductors, computer chips, silicone rubber

15 **P Phosphorus** 15
glowing white waxy solid (also red and black forms); bones, DNA, energy-storing phosphates (ATP), fertilizer, acids, detergent, matches

16 **S Sulfur** 16
brittle yellow solid; skin, hair, egg yolks, onions, garlic, skunks, hot springs, volcanos, gypsum, rubber, acids, papermaking

17 **Cl Chlorine** 17
greenish poisonous gas; salt (NaCl), bleach, stomach acid, disinfectant, drinking water, swimming pools, PVC plastic pipes and bottles

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

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

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

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

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

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

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

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

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

21 **Co Cobalt** 27
hard metal, magnetic; hard strong steel, cutting tools, turbines

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

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

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

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

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

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

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

29 **Br Bromine** 35
dark red liquid; disinfectant, pools and spas, photo film, flame retardant, leaded gasoline, sedatives

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

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

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

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

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

35 **Nb Niobium** 41
high-melting-point non-corroding metal; hard steel, cutting tools, drill bits, armor plate, gun barrels, fertilizer

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

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

38 **Ru Ruthenium** 44
non-corroding hard metal; electric contacts, leaf switches, thermocouples, catalyst

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

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

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

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

43 **In Indium** 49
soft metal; solders, glass seals, liquid crystal displays (LCDs), semiconductors, diodes, photocells

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

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

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

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

48 **At Astatine** 85
radioactive, short-lived; small traces in nature, cancer medicine

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

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

51 **Ba Barium** 56
soft metal; absorbs X-rays; stomach X-ray contrast enhancer, green fireworks, whitener and filler for paper, plastic, and rubber

52 **La Lanthanum** 57
soft metal; optical glass, telescope eyepieces, camera lenses, lighter flints, arc lamps

53 **Ce Cerium** 58
soft metal; most abundant rare earth metal, lighter flints, gas lamp mantles, self-cleaning ovens, glass polishing

54 **Pr Praseodymium** 59
soft metal; torchworkers' didymum eye-glasses (Pr-Nd), lighter flints, arc lamps, magnets, yellow glass

55 **Nd Neodymium** 60
soft metal; strong magnets (Nd-Fe-B), electric motors, headphones, lasers, lighter flints

56 **Pm Promethium** 61
radioactive, long-lived; human-made, small traces in nature, luminous dials, sheet thickness gauges

57 **Sm Samarium** 62
soft metal; magnets (Sm-Co), electric motors, speakers and headphones, infrared sensors, infrared-absorbing glass

58 **Eu Europium** 63
soft metal; phosphors in color TVs and trichromatic lamps, luminous paint, lasers

59 **Gd Gadolinium** 64
soft metal, best neutron absorber, magnetic; magnetic resonance imaging (MRI) contrast enhancer, phosphors, neutron radiography

60 **Tb Terbium** 65
soft metal; phosphors in color TVs and computer disks, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)

61 **Dy Dysprosium** 66
soft metal; nuclear control rods, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)

62 **Ho Holmium** 67
soft metal; infrared lasers, laser surgery, eye-safe laser rangefinders, computer disks, yellow glass filters

63 **Er Erbium** 68
soft metal; fiber optic signal amplifiers, infrared lasers, laser surgery, pink glasses, vanadium alloys

64 **Tm Thulium** 69
soft metal; rare earth metal, infrared lasers, laser surgery

65 **Yb Ytterbium** 70
soft metal; fiber optic signal amplifiers, fiber lasers, stainless steel alloys

66 **Lu Lutetium** 71
soft metal, densest and hardest rare earth metal; cancer-fighting photodynamic (light-activated) medicine

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

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

69 **Rf Rutherfordium** 104

70 **Db Dubnium** 105

71 **Sg Seaborgium** 106

72 **Bh Bohrium** 107

73 **Hs Hassium** 108

74 **Mt Meitnerium** 109

75 **Ds Darmstadtium** 110

76 **Rg Roentgenium** 111

77 **Cn Copernicium** 112

78 **Nh Nihonium** 113

79 **Fl Flerovium** 114

80 **Mc Moscovium** 115

81 **Lv Livermorium** 116

82 **Ts Tennessine** 117

83 **Og Oganesson** 118

84 **La Lanthanum** 57
soft metal; optical glass, telescope eyepieces, camera lenses, lighter flints, arc lamps

85 **Ce Cerium** 58
soft metal; most abundant rare earth metal, lighter flints, gas lamp mantles, self-cleaning ovens, glass polishing

86 **Pr Praseodymium** 59
soft metal; torchworkers' didymum eye-glasses (Pr-Nd), lighter flints, arc lamps, magnets, yellow glass

87 **Nd Neodymium** 60
soft metal; strong magnets (Nd-Fe-B), electric motors, headphones, lasers, lighter flints

88 **Pm Promethium** 61
radioactive, long-lived; human-made, small traces in nature, luminous dials, sheet thickness gauges

89 **Sm Samarium** 62
soft metal; magnets (Sm-Co), electric motors, speakers and headphones, infrared sensors, infrared-absorbing glass

90 **Eu Europium** 63
soft metal; phosphors in color TVs and trichromatic lamps, luminous paint, lasers

91 **Gd Gadolinium** 64
soft metal, best neutron absorber, magnetic; magnetic resonance imaging (MRI) contrast enhancer, phosphors, neutron radiography

92 **Tb Terbium** 65
soft metal; phosphors in color TVs and computer disks, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)

93 **Dy Dysprosium** 66
soft metal; nuclear control rods, MRI phosphors, magnetostrictive smart materials (Terfenol-D®)

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soft metal; infrared lasers, laser surgery, eye-safe laser rangefinders, computer disks, yellow glass filters

95 **Er Erbium** 68
soft metal; fiber optic signal amplifiers, infrared lasers, laser surgery, pink glasses, vanadium alloys

96 **Tm Thulium** 69
soft metal; rare earth metal, infrared lasers, laser surgery

97 **Yb Ytterbium** 70
soft metal; fiber optic signal amplifiers, fiber lasers, stainless steel alloys

98 **Lu Lutetium** 71
soft metal, densest and hardest rare earth metal; cancer-fighting photodynamic (light-activated) medicine

89 **Ac Actinium** 89
radioactive, long-lived; small traces in nature, cancer medicine, neutron source, radwaste

90 **Th Thorium** 90
radioactive, long-lived; most abundant radioactive element, nuclear reactor fuel, gas lamp mantles, tungsten filaments

91 **Pa Protactinium** 91
radioactive, long-lived; small traces in nature, no uses, radwaste

92 **U Uranium** 92
radioactive, long-lived, dense; nuclear reactor fuel, nuclear weapons, counterweights, armor piercing bullets

93 **Np Neptunium** 93
radioactive, long-lived; small traces in nature, neutron detectors, dosimeters, nuclear weapons, radwaste

94 **Pu Plutonium** 94
radioactive, long-lived; small traces in nature, nuclear reactor fuel, spacecraft power, nuclear weapons

95 **Am Americium** 95
radioactive, long-lived; never found in nature, smoke detectors, sheet thickness gauges, radwaste

96 **Cm Curium** 96
radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste

97 **Bk Berkelium** 97
radioactive, long-lived; never found in nature, no uses, radwaste

98 **Cf Californium** 98
radioactive, long-lived; never found in nature, scientific instruments, mineral analyzers, radwaste

99 **Es Einsteinium** 99

100 **Fm Fermium** 100

101 **Md Mendelevium** 101

102 **No Nobelium** 102

103 **Lr Lawrencium** 103

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

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

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105 **Hs Hassium** 108

106 **Mt Meitnerium** 109

107 **Ds Darmstadtium** 110

108 **Rg Roentgenium** 111

109 **Cn Copernicium** 112

110 **Nh Nihonium** 113

111 **Fl Flerovium** 114

112 **Mc Moscovium** 115

113 **Lv Livermorium** 116

114 **Ts Tennessine** 117

115 **Og Oganesson** 118

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".

elements.wlonk.com

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