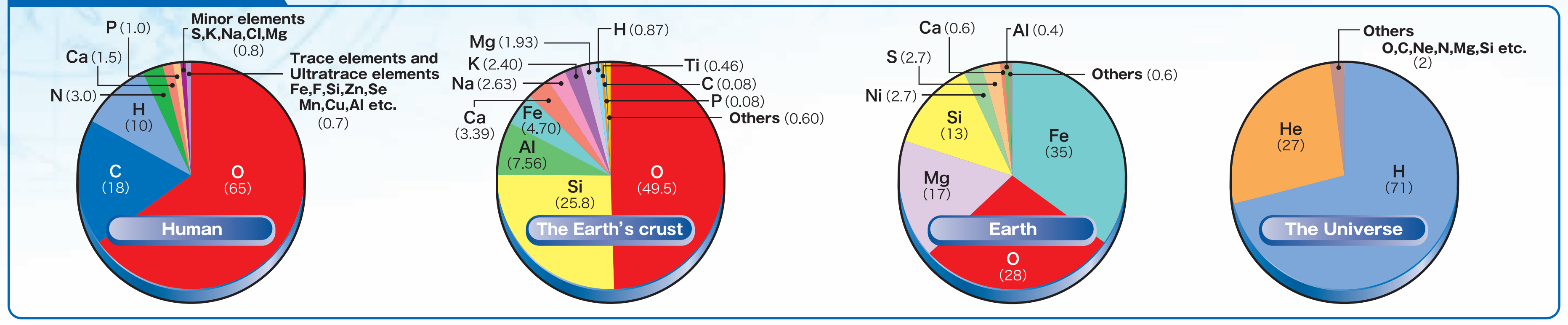
Periodic Table of the Elements

Nature and life are written in the symbols of the elements

Dmitri Mendeleev (1834～1907)

In 1869, the chemist Mendeleev of the Saint Petersburg State University in Russia found the Periodic Law and created the Periodic Table of the Elements using the 63 elements known at the time by arranging them in the order of (1) their atomic weights, and (2) the oxidation states, i.e., the composition of compound bound with oxygen or chlorine (for example, sodium makes NaCl and magnesium makes $MgCl_2$). He found that the elements with similar characteristics appeared periodically in the same column. There were several blank cells for unknown elements in the Table, for which he predicted the characteristics. Although Mendeleev's Periodic Table did not get much attention at first, but once gallium was discovered in 1875 and germanium in 1886, with characteristics just as predicted, it became trusted world-wide. Nowadays, the Periodic Table is the basis of chemistry and physics that is used by everyone.
The year of 2019 is the 150th anniversary of the discovery of the Periodic System of the Elements by Mendeleev.

Element abundance ratio



group / period

Period 1

Group 1 — 1 Hydrogen (H) 1.008
Rocket fuel, fuel cell (car), Ni-H battery. Hydrogen bonds of the DNA double helix. Water, sulfuric acid, citric acid, amino acid. MRI diagnosis, the first antimatter: anti-hydrogen.

Group 18 — 2 Helium (He) 4.003
Gas lighter than air, used in airships. Generated through fusion reactions like the big bang or in the sun. Liquid He is a coolant for superconducting magnets. Makes voice high if inhaled.

Period 2

3 Lithium (Li) 6.941
Lithium ion secondary battery (electric vehicle, smartphone, drone etc.). Lightweight Li alloys used in aircraft construction. Lithium carbonate in medication for manic depression.

Group 2 — 4 Beryllium (Be) 9.012
A component of emerald (birthstone for May). Parts of strong spring machines (Be alloys). Material used for X-ray windows. Am-Be neutron source for research.

Group 13 — 5 Boron (B) 10.81
Heat-resistant glass, glass fibers. Boronic acid balls exterminating cockroaches. Neutron capture therapy for brain tumors. Boron nitride is hard like diamond.

Group 14 — 6 Carbon (C) 12.01
Essential element for living organisms. Plastic, rubber, synthetic fibers, carbon fibers. Diamond, carbon nanotube, fullerene. Pencil, ink stick, charcoal (water purifiers, deodorants).

Group 15 — 7 Nitrogen (N) 14.01
Makes up about 78% of volume of air. One of the three components in fertilizers. Ammonia, amino acids, protein, DNA. Liquid N_2 is an excellent coolant (−196 °C).

Group 16 — 8 Oxygen (O) 16.00
Makes up about 21% of volume of air. Oxygen on earth is produced through photosynthesis. Essential for combustion and biological respiration. Ozone (O_3) blocks UV rays.

Group 17 — 9 Fluorine (F) 19.00
Fluoro-resin is heat resistant and repels water and oil. Decay preventing toothpaste. Hydrogen fluoride dissolves glass. Some fluorocarbons destroy the ozone layer.

10 Neon (Ne) 20.18
Neon signs. Medium for laser light generation. Neon tubes are used in lightning towers. Noble gas abundant next to Ar in the air.

Period 3

11 Sodium (Na) 22.99
Salt NaCl is the main component of sea water. Na lamps inside tunnels, Na/S storage battery Silver colored metal, reacts vigorously with water. Baking powder (sodium bicarbonate).

12 Magnesium (Mg) 24.31
Exists within chlorophyll. Component of bittern (magnesium chloride). Lightweight alloys material used in cars and airplanes Advanced reagents for organic synthesis.

13 Aluminum (Al) 26.98
Aluminum foil, aluminum can, aluminum sash. The main component of alum. Gastric medicine (aluminum hydroxide gel). Sapphire is Al_2O_3 containing metals.

14 Silicon (Si) 28.09
A leading semiconductor, solar cells. Main component of sand, glass and cement. Silicone (oil, rubber, resin). Optical fiber (SiO_2).

15 Phosphorus (P) 30.97
Source of energy for living organisms. Components of DNA, RNA and ATP. One of the three components of fertilizers. Calcium phosphate is a component of bone.

16 Sulfur (S) 32.07
Natural rubber additives to increase elasticity. The main component of neutral detergents. Sulfur smell in hot spas, garlic and onions. S-containing methionine is an essential amino acid.

17 Chlorine (Cl) 35.45
Bleach (sodium hypochlorite). PVC pipe (polyvinyl chloride). Dry cleaning detergents. Component of salt. HCl is a component of gastric acid.

18 Argon (Ar) 39.95
Making up about 1% of the volume of air. Antioxidant gas during welding. Light bulb and fluorescent lamp filled with argon. Ar laser for medical use (retinal detachment surgery).

Period 4

19 Potassium (K) 39.10
One of three components of fertilizers. Seed crystals for artificial rain (KCl). Rock dating method (K-Ar method). Emergency oxygen generating agent (KO_2).

20 Calcium (Ca) 40.08
Main component of bones Osteoporosis may result if deficient. The main component of marble, gypsum and cement Limestone caves, coral reefs.

Group 3 — 21 Scandium (Sc) 44.96
Lighting for outdoor sports. Light weight frame for racing bicycles. Germination promoter (H_2O solution of sulfuric acid salt). Component of reinforced alloys used in aircrafts.

Group 4 — 22 Titanium (Ti) 47.87
The right half is treated with TiO_2
TiO_2 is a photo-catalyst and white pigment. Lightweight and hard metal, artificial bone (non-toxic). Polymerization catalyst for ethylene and propylene. $BaTiO_3$ is an advanced capacitor material.

Group 5 — 23 Vanadium (V) 50.94
Vanadium steel is used in hard tools. Oxidation catalyst for preparation of sulfuric acid. Reduces blood sugar. Contained in some types of mushrooms and sea squirts.

Group 6 — 24 Chromium (Cr) 52.00
Chrome plating (brilliant luster). Stainless steel (Cr-Ni-Fe alloys). Nichrome wire for electrical heaters. Colored component of ruby (Cr-containing Al_2O_3).

Group 7 — 25 Manganese (Mn) 54.94
Impact resistant manganese steel. Manganese cell. Manganese nodules in the ocean floor. Excessive intake enlarges thyroid glands.

Group 8 — 26 Iron (Fe) 55.85
Structural material for buildings, cars, ships, etc. Magnetic metal. Hemoglobin containing Fe carries oxygen. Magnetic tape, disc, and ticket.

Group 9 — 27 Cobalt (Co) 58.93
Perpendicular magnetic recording hard disks (Co-Cr alloys). The central atom of vitamin B_{12} molecule. KS magnetic steel. Blue oil paint (cobalt blue).

Group 10 — 28 Nickel (Ni) 58.69
Turbine wings for jets (Ni super-alloys). Nichrome wire for electric heaters. NiCd batteries. Shape memory alloys (Ti-Ni alloys).

Group 11 — 29 Copper (Cu) 63.55
High-temperature superconductors are copper oxide. Transmits electricity and heat well (electric wires or pans). The main component of bronze or brass. Respiration pigments of prawn, octopus and squid.

Group 12 — 30 Zinc (Zn) 65.38
Brass (Cu-Zn alloys). ZnO as white paint and ointment. Galvanized iron sheet (Zn-plating). Essential in cells for sensing taste.

31 Gallium (Ga) 69.72
GaN semiconductors (blue light emitting diode, LED light bulb), laser for Blu-ray GaAs semiconductors (mobile phones etc.). Metal with low melting point (29.8°C).

32 Germanium (Ge) 72.63
Early stage semiconductor material. Realized the first transistor radio Infrared lens or prisms. Increases the refraction index of optical fibers.

33 Arsenic (As) 74.92
Materials for semiconductors (GaAs, InAs etc.). Barcode readers. Trace constituents in sea weeds (Hijiki), oysters etc. Medicine for a type of leukemia (As_2O_3).

34 Selenium (Se) 78.97
Optical imaging tube for night-vision cameras. Raw material for shielding glass. Bio essential trace element. Japan is the biggest producer in the world.

35 Bromine (Br) 79.90
Bromide photos (after light-sensitive silver bromide). Component of emperor purple dye (Tyrian purple). Red liquid under normal temperature (melting points −7.2°C).

36 Krypton (Kr) 83.80
Derived from Greek meaning "a hidden item". One of the rarest gases on earth. Bright krypton light bulb. Inhaling makes the voice low.

Period 5

37 Rubidium (Rb) 85.47
Removes residual oxygen in vacuum tubes. Rubidium atomic clock (0.1 second error per year). Dating method for meteorites and rocks (Rb-Sr method).

38 Strontium (Sr) 87.62
Fireworks and warning signal light (scarlet). Radioactive isotopes used as pain reliever for bone tumors. Optical lattice clock (1 second error per 30 billion years).

39 Yttrium (Y) 88.91
Powerful YAG (Y-Al garnet) solid-state laser. Y-Fe garnet is a magneto-optical material. Phosphor for liquid crystal display.

40 Zirconium (Zr) 91.22
Strong ceramics. Used in the tip of the space shuttle. Imitation diamond (zirconia).

41 Niobium (Nb) 92.91
Nb/Ti alloys superconducting magnet coils (linear motor vehicles and image diagnostic MRI devices). Ultra-thin glasses (Nb-containing glass with high refractive index). Heat-resistant alloys (aircraft engines).

42 Molybdenum (Mo) 95.95
Solid lubricant for bearings (MoS_2). Active center of aerial nitrogen fixation enzymes (Rhizobia of leguminous plants). Catalyst to remove sulfur from petroleum.

43 Technetium (Tc) (99)
Half-life 213 thousand years
The first artificially produced radioactive element (1937). Derived from Greek *technētos* meaning man-made. Isotope with half-life of approximately 6 hours used as tumor diagnostic agent, imaging with systemic distribution.

44 Ruthenium (Ru) 101.1
Hydrogenation catalyst, carbon skeleton transformation catalyst. Increases the storage capacity of hard disk. Electronic contacts, resistors, pen tips. Electrodes for brine electrolysis (chlorine production).

45 Rhodium (Rh) 102.9
Automotive exhaust gas purification catalyst. Hydrogenation catalyst, catalyst for synthesis of acetic acid. Surface Rh plating of silver ornaments.

46 Palladium (Pd) 106.4
Acetaldehyde synthesis plant (WACKER)
Catalysts for hydrogenation, acetaldehyde synthesis and cross-coupling. Stores 900 times its volume of hydrogen. Automotive exhaust gas purification catalyst.

47 Silver (Ag) 107.9
Photographic films, printing paper (AgBr, AgI). Silver coins, tablewares, ornaments, backing of mirrors. Alloys for dental treatment. Silver ion has anti-bacterial and deodorant properties.

48 Cadmium (Cd) 112.4
NiCd batteries. Cadmium yellow pigment (CdS). Radiation detector (CdTe). Itai-itai disease is Cd poisoning.

49 Indium (In) 114.8
Transparent conductive film in liquid crystal display. IGZO semiconductors realized energy-saving displays. Semiconductor for infrared detectors etc. Radioisotopes are medical diagnostic agents.

50 Tin (Sn) 118.7
Tin-plated steel plate. The main component of solder. Bronze (Cu-Sn alloys). Tin tablewares and pipe organ.

51 Antimony (Sb) 121.8
Sb-Pb alloys used as type fonts. Antimony oxide is a flame-retardant promoter for plastics, curtains, and mattresses. Semiconductor, DVD/Blu-ray disk.

52 Tellurium (Te) 127.6
DVD/Blu-ray disk [Ge-Sb-Te: melts instantaneously by laser irradiation and turns into amorphous state]. Material for detecting infrared rays (Sn-Pb-Te).

53 Iodine (I) 126.9
Mouthwash and disinfectants. Chiba prefecture in Japan is the world's number two producer. Iodine-starch reaction : blue-violet. Accumulates in the thyroid gland.

54 Xenon (Xe) 131.3
Asteroid explorer Hayabusa ©JAXA
Ion engine for deep space exploration machine. Strobes for high-speed photography. Filler gas for plasma display panel (PDP).

Period 6

55 Cesium (Cs) 132.9
Standard for the unit of 'second' (1967). Cesium clock used in global positioning systems (GPS) (1 second error per 300 thousand years). Radiation measurement and medical diagnosis.

56 Barium (Ba) 137.3
Contrast medium for X-ray diagnosis of digestive organs (barium sulfate). Lubricant for oil mining machine. Green component in fireworks. Phosphor for liquid crystal display (blue).

Lanthanoid 57 ～ 71
Fifteen elements from 57 to 71 have similar chemical properties and are called lanthanoid elements. Seventeen elements added the 3rd Group elements Sc and Y are collectively referred to rare earth elements.

72 Hafnium (Hf) 178.5
Advanced neutron absorbers (reactor control rods). Discovered from the mineral zircon. Fireproof ceramics (Hafnium nitride). HfO_2 is an advanced material for transistor.

73 Tantalum (Ta) 180.9
Dental implants material. Miniature large-capacity capacitor. Contrast agent for X-ray diagnosis. Miniature wave filter for mobile phones.

74 Tungsten (W) 183.8
Filament for incandescent light bulbs. Has the highest melting point of all metals. Cemented carbide (WC-Co alloys) used in drills etc. X-ray shielding apron.

75 Rhenium (Re) 186.2
Sensor for high temperature (W-Re thermocouple over 2000°C). Filament for mass spectrometer. Materials for electrical connections such as switches.

76 Osmium (Os) 190.2
Tips of fountain pens (Re-Ir alloys). Osmium tetroxide OsO_4 is an oxidizing agent, oxidation catalyst and biological tissue fixative. Dating of meteorites (Re-Os method).

77 Iridium (Ir) 192.2
International metric Prototype
Metals that deteriorate the least. Element concentrated locally by a giant meteorite that hit the earth (a cause of dinosaur extinction). The old metric prototype was Pt-Ir alloys.

78 Platinum (Pt) 195.1
International kilogram Prototype
Materials for accessories or coins. Material for electrodes in fuel cells, automotive exhaust gas catalyst. Anticancer drugs (cisplatin). The past kilogram prototype (abolished in 2019).

79 Gold (Au) 197.0
Gold coins and ornaments. Electronic circuit electrodes. Glass coloring (red cut glass). Anti-rheumatic drugs (Au compounds).

80 Mercury (Hg) 200.6
Image at the time of construction
Liquid metal (melting point −38.8°C). Makes alloys (amalgam) with various metals. Gold amalgam was used for gold plating of the Great Buddha of Nara in the mid 8th century. Minamata disease was caused by methylmercury poisoning.

81 Thallium (Tl) 204.4
Tomogram of the heart
Radioisotope is used as myocardial diagnostic agents. Metal halogen lamp (green light emission). Optical materials for far-infrared radiation. Sometimes used to exterminate mice.

82 Lead (Pb) 207.2
Lead storage battery and car batteries. IC card or printing head of inkjet printer. Pb-Sb alloys used as type fonts. Radiation shielding materials (lead glass).

83 Bismuth (Bi) 209.0
A key element for copper-oxide based high-temperature superconducting cables without transmission loss. Practical thermoelectric conversion elements (Bi_2Te_3, etc.). Low-melting alloys for sprinkler heads etc.

84 Polonium (Po) (210)
Poland · Warsaw · Marie Curie Museum · Half-life 138 days
Discovered by the Curies, Pierre and Marie, in 1898. Named after her home country, Poland. Alpha-ray source and neutron source. Nuclear battery.

85 Astatine (At) (210)
Japan's first cyclotron (1937) · Half-life 8.1 hours
Derived from the Greek *astatos* meaning "unstable". Made artificially in the cyclotron (1940). Expected as a next generation anti-cancer drug using alpha rays.

86 Radon (Rn) (222)
The heaviest gas. Generated from radioactive Ra in small amounts. Radon spring or radium spring. ^{222}Rn has a half-life of 3.8 days.

Period 7

87 Francium (Fr) (223)
France · Paris · L'Institut Curie · Half-life 21.8 min
Discovered by Marguerite Perey in the Curie Institute and named after her birth country, France. The last element discovered from nature in 1939.

88 Radium (Ra) (226)
Half-life 1600 years
Discovered by the Curies, Pierre and Marie, in 1898. Derived from the Latin word *radius* (radiation). One of the rarest elements in the crust, like Po, Ac, Rn, etc.

Actinoid 89 ～ 103
Fifteen elements from 89 to 103 have similar chemical properties and are called actinoid elements. All are radioactive elements.

104 Rutherfordium (Rf) (267)
Half-life 1.3 hours
Named after the British physicist, Ernest Rutherford, who proposed the atomic model (1911).

105 Dubnium (Db) (268)
Russia · Moscow · Dubna · Half-life 29 hours
Made in Joint Institute for Nuclear Research based, Dubna, Russia.

106 Seaborgium (Sg) (271)
Half-life 1.9 min
Named after the U.S. physicist Glenn Seaborg who made 9 artificial elements.

107 Bohrium (Bh) (272)
Half-life 0.083 sec
Named after the Danish physicist Niels Bohr who established quantum mechanics.

108 Hassium (Hs) (277)
Land Hessen · Berlin · Germany · Half-life 0.003 sec
Named after the Latin name of Hessen in Germany, *Hassia*.

109 Meitnerium (Mt) (276)
Half-life 0.72 sec
Named after the Austrian female physicist Lise Meitner who first proved the nuclear fission reaction.

110 Darmstadtium (Ds) (281)
Half-life 11 sec · Darmstadt · Berlin · Germany
Made in The GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany.

111 Roentgenium (Rg) (280)
Half-life 3.6 sec
Named after the German physicist Wilhelm Roentgen who discovered X-rays.

112 Copernicium (Cn) (285)
Half-life 29 sec
Named after the Polish astronomer Nicolaus Copernicus who proposed the heliocentric theory.

113 Nihonium (Nh) (278)
GARIS&Dr. Morita · Half-life 0.0014 sec
Japan's first new element prepared and discovered three by Kosuke Morita et al. during 2004–2012 using an accelerator in RIKEN.

114 Flerovium (Fl) (289)
Half-life 2.1 sec
Named after the Russian nuclear physicist Georgy Flerov.

115 Moscovium (Mc) (289)
Half-life 0.22 sec
Named after Moscow State with Russia's Joint Institute for Nuclear Research.

116 Livermorium (Lv) (293)
Half-life 0.053 sec
Named after the Lawrence Livermore National Laboratory in Livermore, California, U.S.

117 Tennessine (Ts) (293)
Half-life 0.014 sec
Named after Tennessee, U.S., where the research team based at Oak Ridge National Laboratory are located.

118 Oganesson (Og) (294)
Half-life 0.00089 sec
Named after the Russian nuclear physicist Yuri Oganessian.

Lanthanoids

57 Lanthanum (La) 138.9
Raw material for optical glass with high refractive index and super-low dispersion. Hydrogen storage alloys $LaNi_5$ is a basic composition of the anode material in nickel metal hydride (Ni-MH) rechargeable battery. LaB_6 is used in electron beam generating electrodes.

58 Cerium (Ce) 140.1
Yellow phosphor for LED light bulbs. Green phosphor for liquid crystal display UV cut glass, polish for glass. Cleaning device (co-catalyst) for automotive exhaust gases.

59 Praseodymium (Pr) 140.9
Goggles for welding work. Yellow green glaze for pottery (pastel color). Glass coloring (yellow and green).

60 Neodymium (Nd) 144.2
The strongest neodymium magnet. Nd-Fe-B (electric vehicle motor, wind power generator, speakers, etc.). Nd-containing YAG laser (laser knife).

61 Promethium (Pm) (145)
Half-life 17.7 years
Artificial radioactive element made in a nuclear reactor (1940). Atomic battery (power source in deep space). Derived from Greek mythological god Prometheus, who gave the fire to humanity.

62 Samarium (Sm) 150.4
High heat resistant samarium magnet [the first "WALKMAN"-portable audio player (1979)]. Dating method of ancient times. Named after the Russian mining engineer Samarsky.

63 Europium (Eu) 152.0
Red and blue phosphor for liquid crystal displays. Fluorescent labelling agent for immune response. Day-light colored fluorescent lamp. Named in honor of Europe.

64 Gadolinium (Gd) 157.3
Johan Gadolin
Image enhancing agent for medical diagnostic MRI. Thermal neutron radiography (internal transmission test method for metals and plants). Basic component for magnetic refrigeration.

65 Terbium (Tb) 158.9
The main element in materials that stretch and shrink under magnetic field (electric assisted bicycle). Green phosphor for liquid crystal display. X-ray sensitizer.

66 Dysprosium (Dy) 162.5
Essential element in heat-resistant Nd magnet (industrial robot arms etc.). Luminescent paint (combined with Eu). Metal-halide lamps for powerful light source.

67 Holmium (Ho) 164.9
Low heat-generating Ho laser for surgery (lithotrity, prostatectomy). Coloring for artificial jewels (pale yellow).

68 Erbium (Er) 167.3
Optical fiber amplifier for long-distance optical communication [connected between Kyushu and Okinawa (1995)]. Medical laser. Protective goggles for lasers.

69 Thulium (Tm) 168.9
Radiation dosimeter. Blue fluorescence (doped with zinc sulfide). Increases the transmission capacity of the Er-based optical fiber amplifier.

70 Ytterbium (Yb) 173.0
Sweden · Ytterby · Stockholm
Named after Ytterby village (Sweden) where four elements (Y, Tb, Er, Yb) were discovered. Glass coloring (yellow green).

71 Lutetium (Lu) 175.0
^{176}Lu (half-life approx. 36-38 billion years) is used for dating (Lu-Hf method). Used in positron detectors for PET diagnosis.

Actinoids

89 Actinium (Ac) (227)
Half-life 21.8 years
Discovered from pitchblende in 1899. Derived from the Greek word *aktis* (radiation). Used as a neutron source.

90 Thorium (Th) 232.0
Half-life 14 billion years
Th containing W in several % is an excellent arc welding electrode. ThO_2 is a thermally stable compound (melting point 3300°C).

91 Protactinium (Pa) 231.0
Half-life 32.5 thousand years
^{231}Pa is used for the dating of the manganese nodule (cf., Mn). Named to mean an element prior to actinium.

92 Uranium (U) 238.0
Half-life 4.5 billion years
Enriched uranium ^{235}U triggers nuclear fission chain reactions (nuclear power generation). Earth dating (U-Pb method), uranium glass.

93 Neptunium (Np) (237)
Half-life 21.4 thousand years
The first artificial transuranic element (1940). Named after Neptune.

94 Plutonium (Pu) (239)
Half-life 24.1 thousand years
Fuel for fast-breeder reactors. Nuclear battery (space ship). Named after Pluto.

95 Americium (Am) (243)
Half-life 7370 years
^{241}Am was used in smoke-sensitive fire alarms and thickness meters. Composite with Be is a neutron source. Named in honor of America.

96 Curium (Cm) (247)
Half-life 15.6 million years
Named after the Curies, Pierre and Marie. Made by colliding Pu with alpha particles.

97 Berkelium (Bk) (247)
Half-life 1400 years
Made in a cyclotron at Berkeley, University of California.

98 Californium (Cf) (252)
Half-life 2.64 years
^{252}Cf is used as a neutron source by spontaneous fission for nuclear fuel enrichment measurement and non-destructive inspection.

99 Einsteinium (Es) (252)
Half-life 1.29 years
Named after the physicist Albert Einstein.

100 Fermium (Fm) (257)
Half-life 100.5 days · Enrico Fermi
Fm and Es were discovered from within the dust collected from the world's first hydrogen bomb test site in the U.S.

101 Mendelevium (Md) (258)
Half-life 52 days
Named after Dmitiri Mendeleev, the discoverer of the periodic law of the elements.

102 Nobelium (No) (259)
Half-life 58 min
Named after Alfred Nobel who invented the dynamite and established the Nobel Prize.

103 Lawrencium (Lr) (262)
World's first cyclotron (1932) · Half-life 216 min
Named after Ernest Lawrence, the inventor of the cyclotron (1932).

Legend

C — element symbol
typical applications
Essential element for living organisms. Plastic, rubber, synthetic fibers, carbon fibers. Diamond, carbon nanotube, fullerene. Pencil, ink stick, charcoal (water purifiers, deodorants). — applications, etc.
6 Carbon 12.01 — atomic number, element name, atomic weight

gas / liquid / solid / unknown

One Periodic Table in Every Home

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● References: 1) John Emsley, "The Elements," 3rd Ed.,Oxford University Press (1998). 2) John Emsley, "Nature's Building Blocks: An A-Z Guide to the Elements," Oxford University Press (2011). 3) Albert Stwertka, "A Guide to the Elements (second edition)," Oxford University Press (2002). 4) Periodic Table, published from The Chemical Society of Japan (2017). 5) J. Magill, G. Pfennig, R. Dreher, Z. Sóti, Karlsruher Nuklidkarte, "Karlsruhe chart of the nuclides," 9th ed., Nucleonica (2015).

※ The mass numbers indicated here are expressed by rounding the detailed mass number of each element to 4 significant figures and have been approved by IUPAC Atomic Weight Committee. For elements that have no stable isotopes and whose isotopic natural abundance ratios are not constant, the atomic weight of the representative isotope is shown (Reference 4). Half-lives of the radioactive isotopes are the data for a representative isotope (Reference 1, 2, 5).
Half-life is the time required for the number of atoms or the radioactivity of a radionuclide to be half of the original value. The positions of elements beyond ^{104}Rf in the Periodic Table are provisional.