

PERIODIC TABLE OF THE ELEMENTS

Table of Radioactive Isotopes

Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows:

α alpha particle L L-electron capture
 β⁻ beta particle SF spontaneous fission
 β⁺ positron γ gamma ray
 K K-electron capture e⁻ internal electron conversion

GROUP IA

1	1.00797	1
-252.7	H	
-259.2	Hydrogen	
0.071		

IIA

3	6.939	4	9.0122
1330	Li	2770	Be
180.5	Lithium	1.85	Beryllium
0.53			

Ac 227(22y)β ⁻ ,α	Cd 115(43d)β ⁻ ,γ	Fe 55(2.6y)K	La 140(40.2h)β ⁻ ,γ	Po 210(138.4d)α,γ	Sr 90(28y)β ⁻
Ag 110(24s)β ⁻ ,γ	Ce 141(32d)β ⁻ ,γ	59(45d)β ⁻ ,γ	Lu 176(10 ¹⁰ y)β ⁻ ,K,γ	209(103y)α,K,γ	89(51d)β ⁻ ,γ
111(7.5d)β ⁻ ,γ	143(33h)β ⁻ ,γ	Fm 255(20h)α	177(6.8d)β ⁻ ,γ	143(13.8d)β ⁻	85(64d)K,γ
Am 241(458y)α,γ,e ⁻	144(285d)β ⁻ ,γ	Fr 223(22m)β ⁻ ,γ,α	Md 256(90m)K,SF	Pr 197(118h)β ⁻ ,γ	Ta 182(115d)β ⁻ ,γ
242(16.0h)β ⁻ ,K,α,γ	Cf 246(35h)α,γ,SF	Ga 72(14.1h)β ⁻ ,γ	Mo 99(67h)β ⁻ ,γ	Pu 242(3.8 × 10 ⁵ y)α,SF	Tb 160(73d)β ⁻ ,γ
243(8000y)α,γ	249(360y)α,γ,SF	251(800y)γ	Na 22(2.6y)β ⁺ ,K,γ	241(13y)β ⁻ ,γ,γ,SF	Tc 99(2×10 ⁵ y)β ⁻
As 76(26.7h)β ⁻ ,γ	251(800y)γ	Cl 36(3×10 ⁴ y)β ⁻	Gd 153(236d)K,γ,e ⁻	239(24300y)α,γ,SF	97(10 ⁴ y)K
77(39h)β ⁻ ,γ	Ge 71(11d)K	Ge 71(11d)K	159(18h)β ⁻ ,γ	Ra 226(1620y)α,γ	Te 127(9.3h)β ⁻
At 210(8.3h)K,α,γ	H 3(12.3y)β ⁻	H 3(12.3y)β ⁻	Nd 147(11.1d)β ⁻ ,γ	Rb 86(18.6d)β ⁻ ,γ	Th 232(1.4×10 ¹⁰ y)α,γ,SF
211(7.2h)K,α,γ	Hf 181(45d)β ⁻ ,γ,e ⁻	Hf 181(45d)β ⁻ ,γ,e ⁻	Ni 63(125y)β ⁻	Re 188(16.7h)β ⁻ ,γ	228(1.91y)β ⁻
Au 198(2.69d)β ⁻ ,γ	Co 58(71d)K,β ⁺ ,γ	Co 58(71d)K,β ⁺ ,γ	59(8×10 ⁴ y),K	186(3.7d)β ⁻ ,γ	Ti 204(3.81y)β ⁻ ,K
Ba 131(12d)K,γ	60(5.27y)β ⁻ ,γ	60(5.27y)β ⁻ ,γ	Np 237(2.2×10 ⁶ y)α,γ	Rn 222(3.82d)α	Tm 170(134d)β ⁻ ,γ,e ⁻
133(7.2y)K,γ,e ⁻	Cr 51(27d)K,γ	Cr 51(27d)K,γ	239(2.33d)β ⁻ ,γ	Ru 103(40d)β ⁻ ,γ	U 238(4.5×10 ⁹ y)α,γ,SF
Bi 210(5d)β ⁻ ,α	Cs 134(2.0y)β ⁻ ,γ	Cs 134(2.0y)β ⁻ ,γ	Os 191(15d)β ⁻ ,γ,e ⁻	Sb 122(2.8d)β ⁻ ,K,β ⁺ ,γ	234(2.5×10 ⁵ y)α,γ,SF
Bk 245(4.9d)K,α,γ	135(3×10 ⁴ y)β ⁻	135(3×10 ⁴ y)β ⁻	P 32(14.2d)β ⁻	124(60d)β ⁻ ,γ	235(7.1×10 ⁸ y)α,γ,SF
249(314d)β ⁻ ,α,SF	137(30y)β ⁻ ,γ	137(30y)β ⁻ ,γ	Pa 231(34000y)α,γ	Y 90(64h)β ⁻ ,e ⁻	233(1.6×10 ⁵ y)α,γ
Br 82(36h)β ⁻ ,γ	Cu 64(12.8h)K,β ⁻ ,β ⁺ ,γ	Cu 64(12.8h)K,β ⁻ ,β ⁺ ,γ	Pb 210(19.4y)β ⁻ ,γ,e ⁻	W 185(75d)β ⁻	Y 90(64h)β ⁻ ,e ⁻
C 14(5700y)β ⁻	Es 253(20d)α,γ,SF	Es 253(20d)α,γ,SF	202(10 ⁵ y)L	Yb 175(4.2d)β ⁻ ,γ	169(31d)K,γ,e ⁻
Ca 40(1.8×10 ¹⁰ y)K	254(1y)α,SF	254(1y)α,SF	Pd 103(17d)K,γ	Zn 65(153(47h)β ⁻ ,γ	65(153(47h)β ⁻ ,γ
41(165d)β ⁻	47(4.5d)β ⁻ ,γ	47(4.5d)β ⁻ ,γ	Pm 147(2.6y)β ⁻	145(340d)K,γ	93(9×10 ⁴ y)β ⁻ ,γ
45(165d)β ⁻	Eu 154(16y)β ⁻ ,γ	Eu 154(16y)β ⁻ ,γ		Sn 113(119d)K,L,γ,e ⁻	
47(4.5d)β ⁻ ,γ	155(1.8y)β ⁻ ,γ	155(1.8y)β ⁻ ,γ			

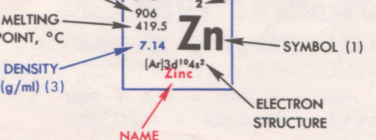
VIIIA

2	4.0026	
-268.9	He	
-269.7	Helium	
0.126		

5	10.811	6	12.01115	7	14.0067	8	15.9994	9	18.9984	10	20.183
(2030)	B	4830 ±4.2	C	-195.8	N	-183	O	-188.2	F	-246	Ne
2.34	Boron	2.26	Carbon	0.81	Nitrogen	1.14	Oxygen	1.505	Fluorine	1.20	Neon
1s ² 2s ² 2p ¹		1s ² 2s ² 2p ²		1s ² 2s ² 2p ³		1s ² 2s ² 2p ⁴		1s ² 2s ² 2p ⁵		1s ² 2s ² 2p ⁶	
13	26.9815	14	28.086	15	30.9738	16	32.064	17	35.453	18	39.948
2450	Al	2680	Si	280w ±3.5, 4	P	444.6 ±2.6	S	-34.7 ±1.3, 5, 7	Cl	-185.8	Ar
660	Aluminum	1410	Silicon	44.2w	Phosphorus	1.82w	Sulfur	2.07	Chlorine	-189.4	Argon
2.70		2.33		1.82w		2.07		1.56		1.40	
[Ne]3s ² 3p ¹		[Ne]3s ² 3p ²		[Ne]3s ² 3p ³		[Ne]3s ² 3p ⁴		[Ne]3s ² 3p ⁵		[Ne]3s ² 3p ⁶	

19	39.102	20	40.08	21	44.956	22	47.90	23	50.942	24	51.996	25	54.938	26	55.847	27	58.933	28	58.71	29	63.54	30	65.37	31	69.72	32	72.59	33	74.922	34	78.96	35	79.909	36	83.80
760	K	1440	Ca	2730	Sc	3260	Ti	3450	V	2665	Cr	2150	Mn	3000	Fe	2900	Co	2730	Ni	2595	Cu	906	Zn	2237	Ga	2830	Ge	613 ±3.5	As	685	Se	58	Br	-152	Kr
63.7	Potassium	1.55	Calcium	3.0	Scandium	4.51	Titanium	6.1	Vanadium	7.19	Chromium	7.43	Manganese	7.86	Iron	8.9	Cobalt	8.9	Nickel	8.96	Copper	419.5	Zinc	5.91	Gallium	5.32	Germanium	5.72	Arsenic	4.79	Selenium	3.12	Bromine	2.6	Krypton
[Ar]4s ¹		[Ar]4s ²		[Ar]3d ¹ 4s ²		[Ar]3d ² 4s ²		[Ar]3d ³ 4s ²		[Ar]3d ⁴ 4s ¹		[Ar]3d ⁵ 4s ¹		[Ar]3d ⁶ 4s ²		[Ar]3d ⁷ 4s ²		[Ar]3d ⁸ 4s ²		[Ar]3d ⁹ 4s ¹		[Ar]3d ¹⁰ 4s ¹		[Ar]3d ¹⁰ 4s ² 4p ¹		[Ar]3d ¹⁰ 4s ² 4p ²		[Ar]3d ¹⁰ 4s ² 4p ³		[Ar]3d ¹⁰ 4s ² 4p ⁴		[Ar]3d ¹⁰ 4s ² 4p ⁵		[Ar]3d ¹⁰ 4s ² 4p ⁶	

37	85.47	38	87.62	39	88.905	40	91.22	41	92.906	42	95.94	43	(98)	44	101.07	45	102.905	46	106.4	47	107.870	48	112.40	49	114.82	50	118.69	51	121.75	52	127.60	53	126.904	54	131.30
38.9	Rb	1380	Sr	2927	Y	3580	Zr	3300	5.3	2927	Nb	2140	Tc	4900	Ru	4500	Rh	3980	Pd	2210	Ag	2210	Cd	2000	In	2270	Sn	1380	Sb	989.8	Te	183	I	183	Xe
1.53	Rubidium	2.6	Strontium	4.47	Yttrium	6.49	Zirconium	2468	10.2	8.4	Niobium	11.5	Technetium	12.2	Ruthenium	12.4	Rhodium	12.0	Palladium	10.5	Silver	8.65	Cadmium	7.31	Indium	7.30	Tin	6.62	Antimony	4.94	Tellurium	3.06	Iodine	3.06	Xenon
[Kr]5s ¹		[Kr]5s ²		[Kr]4d ¹ 5s ²		[Kr]4d ² 5s ²		[Kr]4d ³ 5s ¹		[Kr]4d ⁴ 5s ¹		[Kr]4d ⁵ 5s ⁰		[Kr]4d ⁶ 5s ¹		[Kr]4d ⁷ 5s ¹		[Kr]4d ⁸ 5s ¹		[Kr]4d ⁹ 5s ¹		[Kr]4d ¹⁰ 5s ¹		[Kr]4d ¹⁰ 5s ² 5p ¹		[Kr]4d ¹⁰ 5s ² 5p ²		[Kr]4d ¹⁰ 5s ² 5p ³		[Kr]4d ¹⁰ 5s ² 5p ⁴		[Kr]4d ¹⁰ 5s ² 5p ⁵		[Kr]4d ¹⁰ 5s ² 5p ⁶	



- NOTES:**
- (1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.
 - Based upon carbon - 12. () indicates most stable or best known isotope.
 - Values for gaseous elements are for liquids at the boiling point.

SARGENT-WELCH

SARGENT-WELCH SCIENTIFIC COMPANY

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TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

Percent Ionic Character of a Single Chemical Bond

Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

GROUP IA

H	0.32	2.1
	0.108	0.014
	2.08(-)	—
Li	1.41	0.004
	3.13	3.45

IIA

Be	1.23	1.0	0.90	1.5
	1.55	32.48	1.12	73.9
	0.60(+)	0.72	0.31(+)	2.8
	—	0.108	—	0.25
Mg	13.1	0.17	5.0	0.38
	124	0.79	215	0.45

Sub-Atomic Particles

Symbol	Electron		Positron		Proton		Neutron		Photon		Neutrino		Meson						Hyperon			
	e^-	β^-	e^+	β^+	p	n	γ	ν	μ^\pm	π^\pm	ρ^\pm	K^\pm	K^0	Λ^0	Σ^\pm	Σ^0	Σ^\pm	Ξ^\pm	Ω^-			
Mass*	1	1	1836.12	1838.65	0	0	0	0	206.84	273.23	264.4	966.6	974.4	2181.4	2327.7	2343.2	2584	1686				
Charge**	-1	+1	+1	0	0	0	0	0	± 1	± 1	0	0	0	0	+1	-1	-1	-1				
Spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	1	$\frac{1}{2}$	0	0	0	0	0	0	$\frac{1}{2}$	$\frac{1}{2}$	integral	integral	integral				
Magnetic Moment	1.00 B.m.	1.00 B.m.	2.793 n.m.	-1.913 n.m.	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Mean Life (sec.)	stable	stable	stable	1.11×10^9	stable	stable	2.22×10^{-6}	2.54×10^{-8}	$\sim 10^{-15}$	$\sim 10^{-8}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$	$\sim 10^{-10}$					
Decay Modes	—	—	$-p + e + \nu$	—	$-e + p + \nu$	—	$-\mu^\pm + \nu$	$e^+ + e^- + \gamma$	complex	complex	$-p + \pi^+$	$-p + \pi^0$	$-p + \pi^-$	$-n + \pi^0$	$-n + \pi^+$	$-n + \pi^-$	$-n + \pi^0$					

B.m. = Bohr magneton n.m. = Nuclear magneton *In units of 9.1083×10^{-31} kg. **In units of 4.80286×10^{-10} esu. †Exists as an antiparticle not listed.

VIIIA

He	0.93	—
	—	0.020
	—	0.005
Ne	31.8	0.003
	56.7	1.25

III A	IV A	V A	VIA	VII A	VIIIA
B	C	N	O	F	Ne
0.82	2.0	0.77	2.5	0.75	3.0
0.98	1.26	0.914	1.717	0.92	0.666
0.20(+)	5.3	2.60(-)	—	1.71(-)	0.086
—	10 ⁻¹²	0.15(+)	0.007	0.11(+)	—
4.6	—	5.3	0.057	17.3	0.0006
191	0.309	260	0.165	336	0.247
138	—	188	0.162	254	0.177
1.18	1.5	1.11	1.8	1.06	2.1
1.43	67.9	1.32	140.6	1.28	2.97
0.50(+)	2.55	2.71(-)	11.1	2.12(-)	0.15
—	0.382	0.41(+)	0.10	0.34(+)	10 ⁻¹⁷
10.0	0.50	12.0	17.0	15.5	0.007
119	0.295	176	0.25	239	0.175
1.26	1.6	1.22	1.8	1.20	2.0
1.41	—	1.37	6.8	1.39	7.75
1.13(+)	1.34	0.93(+)	7.6	2.22(-)	6.62
0.62(+)	0.058	0.53(+)	0.022	0.47(+)	0.029
11.8	0.14	13.6	0.14	13.1	0.14
138	0.079	187	0.073	231	0.082
1.26	1.6	1.22	1.8	1.16	2.4
1.41	—	1.37	6.8	1.40	3.34
1.13(+)	1.34	0.93(+)	7.6	2.22(-)	6.62
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IIIB	IVB	VB	VIB	VII B	VIII	IB	II B				
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
2.03	0.8	1.74	1.0	1.44	1.3	1.32	1.5	1.22	1.6	1.18	1.6
2.35	18.9	1.97	36.74	1.62	81	1.47	106.5	1.30	72.97	1.35	53.7
1.33(+)	—	0.99(+)	2.1	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3
—	0.143	—	0.218	—	0.015	0.48(+)	0.024	0.52(+)	0.078	0.46(+)	0.054
45.3	0.23	29.9	0.3	15.0	0.015	10.6	—	8.35	—	7.23	0.16
100	1.17	141	0.149	151	0.13	158	0.126	156	0.11	171	0.115
2.16	0.8	1.91	1.0	1.62	1.3	1.45	1.4	1.34	1.6	1.30	1.8
2.35	18.9	1.97	36.74	1.62	81	1.47	106.5	1.30	72.97	1.35	53.7
1.33(+)	—	0.99(+)	2.1	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3
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2.16	0.8	1.91	1.0	1.62	1.3	1.45	1.4	1.34	1.6	1.30	1.8
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1.33(+)	—	0.99(+)	2.1	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3
—	0.143	—	0.218	—	0.015	0.48(+)	0.024	0.52(+)	0.078	0.46(+)	0.054
45.3	0.23	29.9	0.3	15.0	0.015	10.6	—	8.35	—	7.23	0.16
100	1.17	141	0.149	151	0.13	158	0.126	156	0.11	171	0.115
2.16	0.8	1.91	1.0	1.62	1.3	1.45	1.4	1.34	1.6	1.30	1.8
2.35	18.9	1.97	36.74	1.62	81	1.47	106.5	1.30	72.97	1.35	53.7
1.33(+)	—	0.99(+)	2.1	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3
—	0.143	—	0.218	—	0.015	0.48(+)	0.024	0.52(+)	0.078	0.46(+)	0.054
45.3	0.23	29.9	0.3	15.0	0.015	10.6	—	8.35	—	7.23	0.16
100	1.17	141	0.149	151	0.13	158	0.126	156	0.11	171	0.115
2.16	0.8	1.91	1.0	1.62	1.3	1.45	1.4	1.34	1.6	1.30	1.8
2.35	18.9	1.97	36.74	1.62	81	1.47	106.5	1.30	72.97	1.35	53.7
1.33(+)	—	0.99(+)	2.1	0.81(+)	3.8	0.90(+)	3.7	0.74(+)	4.2	0.69(+)	3.3
—	0.143	—	0.218	—	0.015	0.48(+)	0.024	0.52(+)	0.078	0.46(+)	0.054
45.3											