THE D-SERIES SET 1, FIRST EDITION

Press Release

Friday, 2 December 2022

To the wider scientific community,

Today marks the first release of the full set one of the D-series of scientific datasheets – with one major exclusion. These datasheets have been produced due to a considerable time investment for the betterment of the established physical sciences and the broader community.

There are eight datasheets total in set one of which seven will today be published. They cover topics across two of the scientific disciplines, chemistry and physics, and serve as a valuable companion to any physical scientist. Each datasheet is produced to a high quality with data sourced from the most reputable scientific institutions, including the European Organization for Nuclear Research, the American National Institute of Standards and Technology, the International Bureau of Weights and Measures, the International Union of Pure and Applied Chemistry and the American National Nuclear Data Center.

The eight datasheets in set one are as follows:

- D1 – Periodic Table of Elements
- D2 – Properties of Elements
- D3 – Properties of Nuclides (Excluded)
- D4 – Standard Model of Elementary Particles
- D5 – Properties of Elementary Particles
- D6 – SI Unit Definitions
- D7 – SI Defining Physical Constants
- D8 – Radioactive Decay Modes
- (Also Present is a Source Document)

Unfortunately, D3 has been omitted from this release due to its current state of completion. Latest estimates indicate that it is only 13.2% complete (by number of nuclides) and that an additional 144 hours would be required to complete the datasheet. For this reason, it has been excluded and will be released at a later date which is to be confirmed.

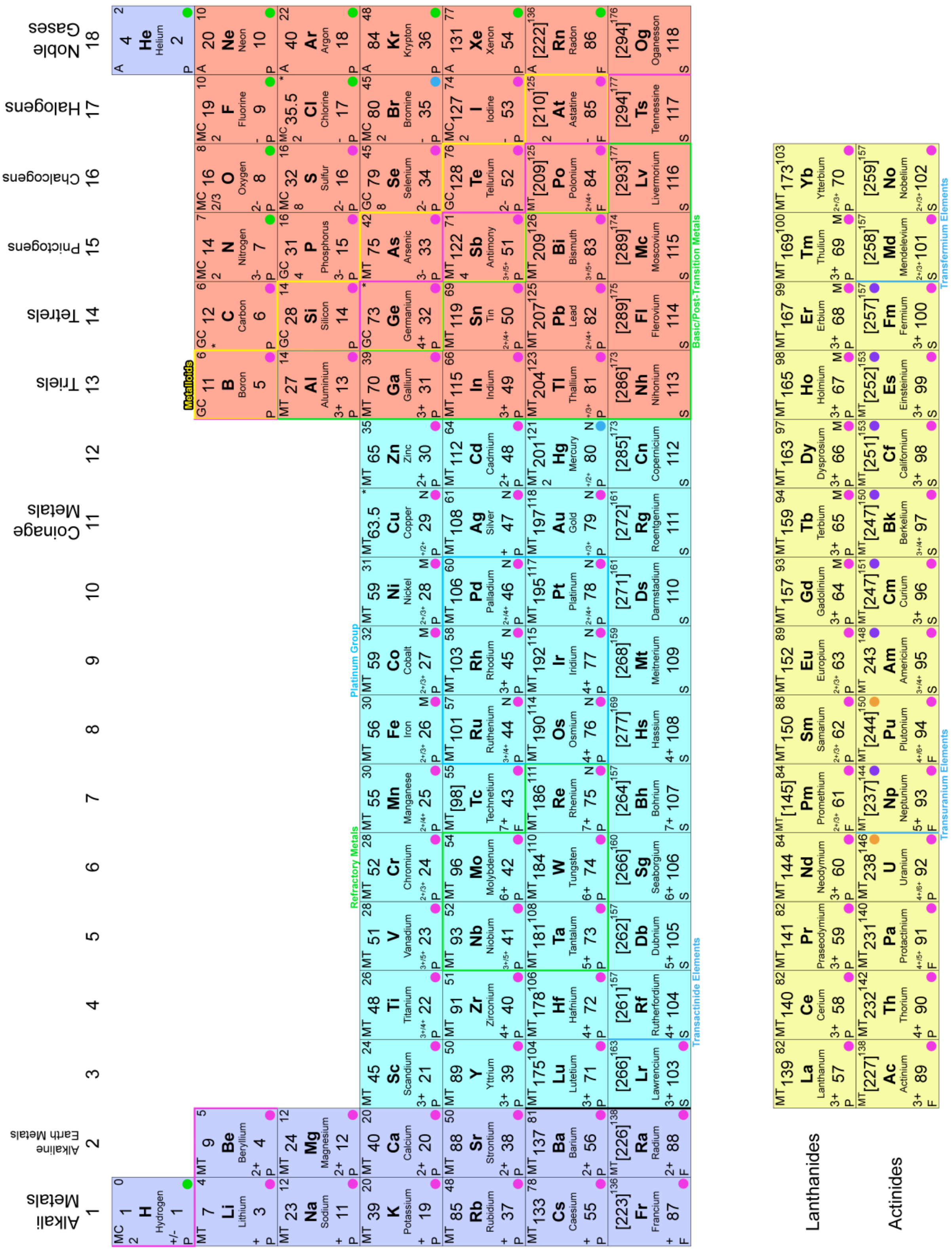
This project is the result of work solely by one person, and whilst all of the datasheets have been produced to a high standard and Harvard format sources have been provided, there may be errors within this work that have not yet been caught. If any error are found, they are to be reported to the author for correction in the next edition and the author has an obligation to find and correct all mistakes that may arise within the work.

Yours Sincerely,

Neo Skinner

Author of the D-Series Datasheet Collection

PERIODIC TABLE OF ELEMENTS (D1)



Key:

Element Representation:

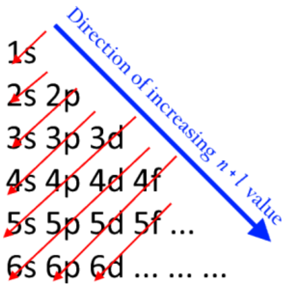
1		*N*
2	*A*	3
	Chemical Symbol	
	Element Name	
4	*Z*	6
5		7

1 Simple Substance Bonding (Symbols are: **MT**, Metallic; **GC**, Giant Covalent; **MC**, Molecular Covalent; **A**, Single Atom)
2 Atomicity (if no number, only 1 atom is present)
N Neutron Number
3 Actinide Type (Symbols are: ●, Major; ●, Minor)
A Mass Number (If bracketed, element is unstable and mass number of the most stable isotope is provided)
Z Atomic/Proton Number
4 Ionic Charge
5 Natural Occurrence (Symbols are: **P**, Primordial; **F**, From Decay; **S**, Synthetic)
6 Additional Properties (Symbols are: **M**, Ferromagnetic; **N**, Noble Metal)
7 State of Matter/Phase at Standard Temperature and Pressure (Symbols are: ●, Solid; ●, Liquid; ●, Gas)

Block Representation:

s p d f

Electron Shell Filling Order:



Sources:

- Simple Substance Bonding, 1 [8] [9] [10] [11] [12] [13] [14]
- Atomicity, 2[25]
- Neutron Number, *N* [2] [3] [4] [5] [6] [7]
- Actinide Type, 3[26]
- Mass Number, *A* [1] [4] [3] [5] [7] [23] [24]
- Chemical Symbol [1] [3] [4] [5] [7] [23] [24]
- Element Name [1] [3] [5] [7] [23] [24]
- Atomic/Proton Number, *Z* [1] [3] [4] [5] [7] [23] [24]
- Ionic Charge, 4 [5] [15] [16] [17]
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PROPERTIES OF ELEMENTS (D2)

Chemical Element Name	**Chemical Symbol**	**Relative Atomic Mass of Isotope with Highest Isotopic Abundance A_r [u or Da]**	**Atomic Number *Z***	**Abbreviated Electron Configuration/ Ground Shells**	**State of Matter/Phase at STP**	**Melting Point/ Liquefaction Point at STP [K]**	**Boiling Point at STP [K]**
Hydrogen	H	1.007 825 032 23(9)	1	$1s^1$	Gas	14.01	20.28
Helium	He	4.002 603 254 13(6)	2	$1s^2$	Gas	0 [No solid state]	4.22
Lithium	Li	7.016 003 436 6(45)	3	[He] $2s^1$	Solid	453.69	1 615
Beryllium	Be	9.012 183 065(82)	4	[He] $2s^2$	Solid	1 560	2 743
Boron	B	11.009 305 36(45)	5	[He] $2s^2$ $2p^1$	Solid	2 348	4 273
Carbon	C	12.000 000 0(00)	6	[He] $2s^2$ $2p^2$	Solid	3 823	4 300
Nitrogen	N	14.003 074 004 43(20)	7	[He] $2s^2$ $2p^3$	Gas	63.1	77.36
Oxygen	O	15.994 914 619 57(17)	8	[He] $2s^2$ $2p^4$	Gas	54.8	90.2
Fluorine	F	18.998 403 162 73(92)	9	[He] $2s^2$ $2p^5$	Gas	53.5	85.03
Neon	Ne	19.992 440 176 2(17)	10	[He] $2s^2$ $2p^6$	Gas	24.56	27.07
Sodium	Na	22.989 769 282 0(19)	11	[Ne] $3s^1$	Solid	370.87	1 156
Magnesium	Mg	23.985 041 697(14)	12	[Ne] $3s^2$	Solid	923	1 363
Aluminium	Al	26.981 538 53(11)	13	[Ne] $3s^2$ $3p^1$	Solid	933.47	2 792
Silicon	Si	27.976 926 534 65(44)	14	[Ne] $3s^2$ $3p^2$	Solid	1 687	3 200

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Phosphorus	P	30.973 761 998 42(70)	15	[Ne] $3s^2$ $3p^3$	Solid	317.3 [Yellow]	553.6 [Yellow]
Sulfur	S	31.972 071 174 4(14)	16	[Ne] $3s^2$ $3p^4$	Solid	388.36	717.87
Chlorine	Cl	34.968 852 682(37)	17	[Ne] $3s^2$ $3p^5$	Gas	171.7	239.11
Argon	Ar	39.962 383 123 7(24)	18	[Ne] $3s^2$ $3p^6$	Gas	83.8	87.4
Potassium	K	38.963 706 486 4(49)	19	[Ar] $4s^1$	Solid	336.53	1 032
Calcium	Ca	39.962 590 863(22)	20	[Ar] $4s^2$	Solid	1 115	1 757
Scandium	Sc	44.955 908 28(77)	21	[Ar] $4s^2$ $3d^1$	Solid	1 814	3 103
Titanium	Ti	47.947 941 98(38)	22	[Ar] $4s^2$ $3d^2$	Solid	1 941	3 560
Vanadium	V	50.943 957 04(94)	23	[Ar] $4s^2$ $3d^3$	Solid	2 183	3 680
Chromium	Cr	51.940 506 23(63)	24	[Ar] $4s^1$ $3d^5$	Solid	2 180	2 944
Manganese	Mn	54.938 043 91(48)	25	[Ar] $4s^2$ $3d^5$	Solid	1 519	2 334
Iron	Fe	55.934 936 33(49)	26	[Ar] $4s^2$ $3d^6$	Solid	1 811	3 134
Cobalt	Co	58.933 194 29(56)	27	[Ar] $4s^2$ $3d^7$	Solid	1 768	3 200
Nickel	Ni	57.935 342 41(52)	28	[Ar] $4s^2$ $3d^8$	Solid	1 728	3 186
Copper	Cu	62.929 597 72(56)	29	[Ar] $4s^1$ $3d^{10}$	Solid	1 357.77	2 835

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Zinc	Zn	63.929 142 01(71)	30	[Ar] $4s^2$ $3d^{10}$	Solid	692.68	1 180
Gallium	Ga	68.925 573 5(13)	31	[Ar] $4s^2$ $3d^{10}$ $4p^1$	Solid	302.91	2 477
Germanium	Ge	73.921 177 761(13)	32	[Ar] $4s^2$ $3d^{10}$ $4p^2$	Solid	1 211	3 093
Arsenic	As	74.921 594 57(95)	33	[Ar] $4s^2$ $3d^{10}$ $4p^3$	Solid	1 090	887
Selenium	Se	79.916 521 8(13)	34	[Ar] $4s^2$ $3d^{10}$ $4p^4$	Solid	494	958
Bromine	Br	78.918 337 6(14)	35	[Ar] $4s^2$ $3d^{10}$ $4p^5$	Liquid	265.8	332
Krypton	Kr	83.911 497 728 2(44)	36	[Ar] $4s^2$ $3d^{10}$ $4p^6$	Gas	115.79	119.93
Rubidium	Rb	84.911 789 737 9(54)	37	[Kr] $5s^1$	Solid	312.46	961
Strontium	Sr	87.905 612 5(12)	38	[Kr] $5s^2$	Solid	1 050	1 655
Yttrium	Y	88.905 840 3(24)	39	[Kr] $5s^2$ $4d^1$	Solid	1 799	3 618
Zirconium	Zr	89.904 697 7(20)	40	[Kr] $5s^2$ $4d^2$	Solid	2 128	4 682
Niobium	Nb	92.906 373 0(20)	41	[Kr] $5s^1$ $4d^4$	Solid	2 750	5 017
Molybdenum	Mo	97.905 404 82(49)	42	[Kr] $5s^1$ $4d^5$	Solid	2 896	4 912
Technetium	Tc	[96.906 366 7(40), 98.906 250 8(10)]	43	[Kr] $5s^2$ $4d^5$	Solid	2 430	4 538
Ruthenium	Ru	101.904 344 1(12)	44	[Kr] $5s^1$ $4d^7$	Solid	2 607	4 423

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Rhodium	Rh	102.905 498 0(26)	45	[Kr] $5s^1$ $4d^8$	Solid	2 237	3 968
Palladium	Pd	105.903 480 4(12)	46	[Kr] $4d^{10}$	Solid	1 828	3 236
Silver	Ag	106.905 091 6(26)	47	[Kr] $5s^1$ $4d^{10}$	Solid	1 234.9	2 435
Cadmium	Cd	113.903 365 09(43)	48	[Kr] $5s^2$ $4d^{10}$	Solid	594.22	1 040
Indium	In	114.903 878 776(12)	49	[Kr] $5s^2$ $4d^{10}$ $5p^1$	Solid	429.8	2 345
Tin	Sn	119.902 201 63(97)	50	[Kr] $5s^2$ $4d^{10}$ $5p^2$	Solid	505.08	2 875
Antimony	Sb	120.903 812 0(30)	51	[Kr] $5s^2$ $4d^{10}$ $5p^3$	Solid	903.78	1 860
Tellurium	Te	129.906 222 748(12)	52	[Kr] $5s^2$ $4d^{10}$ $5p^4$	Solid	722.66	1 261
Iodine	I	126.904 471 9(39)	53	[Kr] $5s^2$ $4d^{10}$ $5p^5$	Solid	386.9	457.5
Xenon	Xe	131.904 155 085 6(56)	54	[Kr] $5s^2$ $4d^{10}$ $5p^6$	Gas	161.3	165
Caesium	Cs	132.905 451 961 0(80)	55	[Xe] $6s^1$	Solid	301.59	944
Barium	Ba	137.905 247 00(31)	56	[Xe] $6s^2$	Solid	1 000	2 143
Lanthanum	La	138.906 356 3(24)	57	[Xe] $6s^2$ $5d^1$	Solid	1 193	3 737
Cerium	Ce	139.905 443 1(23)	58	[Xe] $6s^2$ $4f^1$ $5d^1$	Solid	1 071	3 633
Praseodymium	Pr	140.907 657 6(23)	59	[Xe] $6s^2$ $4f^3$	Solid	1 204	3 563

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Neodymium	Nd	141.907 729 0(20)	60	[Xe] $6s^2$ $4f^4$	Solid	1 294	3 400
Promethium	Pm	[144.912 755 9(33), 146.915 145 0(19)]	61	[Xe] $6s^2$ $4f^5$	Solid	1 400	3 300
Samarium	Sm	151.919 739 7(18)	62	[Xe] $6s^2$ $4f^6$	Solid	1 345	2 067
Europium	Eu	152.921 238 0(18)	63	[Xe] $6s^2$ $4f^7$	Solid	1 095	1 800
Gadolinium	Gd	157.924 112 3(17)	64	[Xe] $6s^2$ $4f^7$ $5d^1$	Solid	1 586	3 523
Terbium	Tb	158.925 354 7(19)	65	[Xe] $6s^2$ $4f^9$	Solid	1 629	3 503
Dysprosium	Dy	163.929 181 9(20)	66	[Xe] $6s^2$ $4f^{10}$	Solid	1 685	2 840
Holmium	Ho	164.930 328 8(21)	67	[Xe] $6s^2$ $4f^{11}$	Solid	1 747	2 973
Erbium	Er	165.930 299 5(22)	68	[Xe] $6s^2$ $4f^{12}$	Solid	1 770	3 141
Thulium	Tm	168.934 217 9(22)	69	[Xe] $6s^2$ $4f^{13}$	Solid	1 818	2 223
Ytterbium	Yb	173.938 866 4(22)	70	[Xe] $6s^2$ $4f^{14}$	Solid	1 092	1 469
Lutetium	Lu	174.940 775 2(20)	71	[Xe] $6s^2$ $4f^{14}$ $5d^1$	Solid	1 936	3 675
Hafnium	Hf	179.946 557 0(20)	72	[Xe] $6s^2$ $4f^{14}$ $5d^2$	Solid	2 506	4 876
Tantalum	Ta	180.947 995 8(20)	73	[Xe] $6s^2$ $4f^{14}$ $5d^3$	Solid	3 290	5 731
Tungsten	W	183.950 930 92(94)	74	[Xe] $6s^2$ $4f^{14}$ $5d^4$	Solid	3 695	5 828

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Rhenium	Re	186.955 750 1(16)	75	[Xe] $6s^2$ $4f^{14}$ $5d^5$	Solid	3 459	5 896
Osmium	Os	191.961 477 0(29)	76	[Xe] $6s^2$ $4f^{14}$ $5d^6$	Solid	3 306	5 285
Iridium	Ir	192.962 921 6(21)	77	[Xe] $6s^2$ $4f^{14}$ $5d^7$	Solid	2 739	4 701
Platinum	Pt	194.964 791 7(10)	78	[Xe] $6s^1$ $4f^{14}$ $5d^9$	Solid	2 041.5	4 098
Gold	Au	196.966 568 79(71)	79	[Xe] $6s^1$ $4f^{14}$ $5d^{10}$	Solid	1 337.33	3 129
Mercury	Hg	201.970 643 40(69)	80	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$	Liquid	234.32	629.88
Thallium	Tl	204.974 427 8(14)	81	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^1$	Solid	577	1 746
Lead	Pb	207.976 652 5(13)	82	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^2$	Solid	600.61	2 022
Bismuth	Bi	208.980 399 1(16)	83	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^3$	Solid	544.4	1 837
Polonium	Po	[208.982 430 8(20), 209.982 874 1(13)]	84	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^4$	Solid	527	1 235
Astatine	At	[209.987 147 9(83), 210.987 496 6(30)]	85	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^5$	Solid	575	-
Radon	Rn	[210.990 601 1(73), 222.017 578 2(25)]	86	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^6$	Gas	202	211.4
Francium	Fr	223.019 736 0(25)	87	[Rn] $7s^1$	Solid	-	-
Radium	Ra	[223.018 502 3(27), 228.031 070 7(26)]	88	[Rn] $7s^2$	Solid	970	2 010
Actinium	Ac	227.027 752 3(25)	89	[Rn] $7s^2$ $6d^1$	Solid	1 323	3 473

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Thorium	Th	232.038 055 8(21)	90	[Rn] $7s^2$ $6d^2$	Solid	2 023	5 093
Protactinium	Pa	231.035 884 2(24)	91	[Rn] $7s^2$ $5f^2$ $6d^1$	Solid	1 845	4 273
Uranium	U	238.050 788 4(20)	92	[Rn] $7s^2$ $5f^3$ $6d^1$	Solid	1 408	4 200
Neptunium	Np	[236.046 570(54), 237.048 173 6(19)]	93	[Rn] $7s^2$ $5f^4$ $6d^1$	Solid	917	4 300
Plutonium	Pu	[238.049 560 1(19), 244.064 205 3(56)]	94	[Rn] $7s^2$ $5f^6$	Solid	913	3 503
Americium	Am	[241.056 829 3(19), 243.061 381 3(24)]	95	[Rn] $7s^2$ $5f^7$	Solid	1 449	2 284
Curium	Cm	[243.061 389 3(22), 248.072 349 9(56)]	96	[Rn] $7s^2$ $5f^7$ $6d^1$	Solid	1 618	3 383
Berkelium	Bk	[247.070 307 3(59), 249.074 987 7(27)]	97	[Rn] $7s^2$ $5f^9$	Solid	1 323 [alpha]	-
Californium	Cf	[249.074 853 9(23), 252.081 627 2(56)]	98	[Rn] $7s^2$ $5f^{10}$	Solid	1 173	-
Einsteinium	Es	252.082 980(54)	99	[Rn] $7s^2$ $5f^{11}$	Solid	1 133	-
Fermium	Fm	257.095 106 1(69)	100	[Rn] $7s^2$ $5f^{12}$	-	1 800	-
Mendelevium	Md	[258.098 431 5(50), 260.103 65(34#)]	101	[Rn] $7s^2$ $5f^{13}$	-	1 100	-
Nobelium	No	259.101 03(11#)	102	[Rn] $7s^2$ $5f^{14}$	-	1 100	-
Lawrencium	Lr	262.109 61(22#)	103	[Rn] $7s^2$ $5f^{14}$ $7p^1$	-	1 900	-
Rutherfordium	Rf	267.121 79(62#)	104	[Rn] $7s^2$ $5f^{14}$ $6d^2$	-	-	-

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Dubnium	Db	268.125 67(57#)	105	[Rn] $7s^2$ $5f^{14}$ $6d^3$	-	-	-
Seaborgium	Sg	271.133 93(63#)	106	[Rn] $7s^2$ $5f^{14}$ $6d^4$	-	-	-
Bohrium	Bh	272.138 26(58#)	107	[Rn] $7s^2$ $5f^{14}$ $6d^5$	-	-	-
Hassium	Hs	270.134 29(27#)	108	[Rn] $7s^2$ $5f^{14}$ $6d^6$	-	-	-
Meitnerium	Mt	276.151 59(59#)	109	[Rn] $7s^2$ $5f^{14}$ $6d^7$	-	-	-
Darmstadtium	Ds	281.164 51(59#)	110	[Rn] $7s^1$ $5f^{14}$ $6d^9$	-	-	-
Roentgenium	Rg	280.165 14(61#)	111	[Rn] $7s^1$ $5f^{14}$ $6d^{10}$	-	-	-
Copernicium	Cn	285.177 12(60#)	112	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$	-	-	-
Nihonium	Nh	284.178 73(62#)	113	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^1$	-	-	-
Flerovium	Fl	289.190 42(60#)	114	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^2$	-	-	-
Moscovium	Mc	288.192 74(62#)	115	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^3$	-	-	-
Livermorium	Lv	293.204 49(60#)	116	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^4$	-	-	-
Tennessine	Ts	292.207 46(75#)	117	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^5$	-	-	-
Oganesson	Og	294.213 92(71#)	118	[Rn] $7s^2$ $5f^{14}$ $6d^{10}$ $7p^6$	-	-	-

Abbreviations and Units:

- STP: Standard Temperature and Pressure
- K: Kelvins
- u or Da: Unified Atomic Mass Unit

Sources:

- Chemical Element Name [1] [2] [20] [21]
- Chemical Symbol [1] [2] [20] [21]
- Relative Atomic Mass of Isotope with Highest Isotopic Abundance, A_r [1] [2] [3] [4] [5] [10] [17]
- Atomic Number, *Z* [1] [2] [20] [21]
- Abbreviated Electron Configuration/Ground Shells [3] [6] [7] [8] [9] [11] [12] [13] [14] [15] [16] [17] [18] [19]
- State of Matter/Phase at STP [3] [10] [17] [21]
- Melting Point/Liquefaction Point at STP [3] [10] [17] [21]
- Boiling Point at STP [3] [10] [17] [21]

STANDARD MODEL OF ELEMENTARY PARTICLES (D4)

Elementary Fermions / Elementary Antifermions

Quarks

I	II	III	I	II	III
2.16 MeV ⅔ ½ **u** Up	1.27 GeV ⅔ ½ **c** Charm	172.69 GeV ⅔ ½ **t** Top	2.16 MeV −⅔ ½ $\bar{u}$ Antiup	1.27 GeV −⅔ ½ $\bar{c}$ Anticharm	172.69 GeV −⅔ ½ $\bar{t}$ Antitop
4.67 MeV −⅓ ½ **d** Down	93.4 MeV −⅓ ½ **s** Strange	4.18 GeV −⅓ ½ **b** Bottom	4.67 MeV ⅓ ½ $\bar{d}$ Antidown	93.4 MeV ⅓ ½ $\bar{s}$ Antistrange	4.18 GeV ⅓ ½ $\bar{b}$ Antibottom

Leptons

I	II	III	I	II	III
0.51 MeV −1 ½ e^- Electron	105.66 MeV −1 ½ μ^- Muon	1776.86 MeV −1 ½ τ^- Tau	0.51 MeV 1 ½ e^+ Positron	105.66 MeV 1 ½ μ^+ Antimuon	1776.86 MeV 1 ½ τ^+ Antitau
<460 eV >0 ½ ν_e Electron Neutrino	<0.19 MeV >0 ½ ν_μ Muon Neutrino	<18.2 MeV >0 ½ ν_τ Tau Neutrino	<1.1 eV >0 ½ $\bar{\nu}_e$ Electron Antineutrino	<0.19 MeV >0 ½ $\bar{\nu}_\mu$ Muon Antineutrino	<18.2 MeV >0 ½ $\bar{\nu}_\tau$ Tau Antineutrino

Elementary Bosons

Gauge Bosons	Scalar Bosons
0 0 1 **g** Gluon	125.25 GeV 0 0 **H** Higgs
>0 eV >0 1 γ Photon	
91.19 GeV 0 1 **Z** Z^0 Boson	
80.38 GeV 1 1 W^+ W^+ Boson	
80.38 GeV −1 1 W^- W^- Boson	

Key:

Elementary Particle Representation:

1
2
3

Particle Symbol

Particle Name

1 Invariant Mass, m, in GeV/c^2, MeV/c^2 and eV/c^2 (Units Simplified on Diagram)
2 Electric Charge, Q, in Elementary Charge Units
3 Spin, s

Sources:

- Invariant Mass, 1[1]
- Electric Charge, 2[1]
- Spin, 3[1]
- Particle Symbol[1]
- Particle Name[1]

PROPERTIES OF ELEMENTARY PARTICLES (D5)

Particle Name	Symbol	Antiparticle	Invariant Mass m_0 [MeV/c²] (Uncertainty)	Electric Charge Q [e]	Type and Sub-type / Generation	Spin S	Mean Life τ [per eV]
Up Quark	u	Antiup ($\bar{u}$)	$2.16^{+0.49}_{-0.26}$	$+\frac{2}{3}$	Quark: Up-type, Gen. I	$\frac{1}{2}$	-
Down Quark	d	Antidown ($\bar{d}$)	$4.67^{+0.48}_{-0.17}$	$-\frac{1}{3}$	Quark: Down-type, Gen. I	$\frac{1}{2}$	-
Charm Quark	c	Anticharm ($\bar{c}$)	1 270.0 ± 20	$+\frac{2}{3}$	Quark: Up-type, Gen. II	$\frac{1}{2}$	-
Strange Quark	s	Antistrange ($\bar{s}$)	$93.4^{+8.6}_{-3.4}$	$-\frac{1}{3}$	Quark: Down-type, Gen. II	$\frac{1}{2}$	-
Top Quark	t	Antitop ($\bar{t}$)	172 690.0 ± 300	$+\frac{2}{3}$	Quark: Up-type, Gen. III	$\frac{1}{2}$	-
Bottom Quark	b	Antibottom ($\bar{b}$)	$4\,180^{+30}_{-20}$	$-\frac{1}{3}$	Quark: Down-type, Gen. III	$\frac{1}{2}$	-
Electron	e	Positron (e^+)	0.510 998 950 00 ± 0.000 000 000 15	-1	Lepton: Charged, Gen. I	$\frac{1}{2}$	> 6.6 × 10^{28} a
Electron Neutrino	ν_e	Electron Antineutrino ($\bar{\nu}_e$)	< 0.000 001 1	< 4 × 10^{-35}	Lepton: Neutral, Gen. I	$\frac{1}{2}$	> 300 s
Muon	μ	Antimuon (μ^+)	105.658 375 5 ± 0.000 002 3	-1	Lepton: Charged, Gen. II	$\frac{1}{2}$	(2.196 981 1 ± 0.000 002 2) × 10^{-6} s
Muon Neutrino	ν_μ	Muon Antineutrino ($\bar{\nu}_\mu$)	< 0.19	< 4 × 10^{-35}	Lepton: Neutral, Gen. II	$\frac{1}{2}$	> 300 s
Tau (Tauon)	τ	Antitau (τ^+)	1 776.86 ± 0.12	-1	Lepton: Charged, Gen. III	$\frac{1}{2}$	(290.3 ± 0.5) × 10^{-15} s
Tau Neutrino	ν_τ	Tau Antineutrino ($\bar{\nu}_\tau$)	< 18.2	< 4 × 10^{-35}	Lepton: Neutral, Gen. III	$\frac{1}{2}$	> 300 s
Photon	γ	-	< 1×10^{-24}	< 1 × 10^{-46}	Boson: Gauge	1	-
Gluon	g	-	0 (Theoretical)	0	Boson: Gauge	1	-
W^+	W^+	-	80 377.0 ± 12	1	Boson: Gauge	1	-

Particle Name	Symbol	Antiparticle	Invariant Mass m_0 [MeV/c^2] (Uncertainty)	Electric Charge Q [e]	Type and Sub-type / Generation	Spin S	Mean Life τ [per eV]
W$^-$	W$^-$	-	80 377.0 ± 12	-1	Boson: Gauge	1	-
Z	Z	-	91 187.6 ± 2.1	0	Boson: Gauge	1	-
Higgs	H^0	-	125 250.0 ± 170	0	Boson: Scalar	0	1.6 × 10^{-22} s

Units:

- MeV/c^2: Megaelectronvolts/Speed of Light^2 (Mass)
- e: Elementary Charge
- a: Year
- s: Second

Sources:

- Particle Name [1] [2]
- Symbol [1] [2]
- Invariant Mass, m_0 [1] [2]
- Electric Charge, Q [1] [2]
- Type and Sub-type/Generation [1] [2]
- Spin, S [1] [2]
- Mean Life, τ [1] [2] [3]

SI UNIT DEFINITIONS (D6)

Base Units

Base Unit	**Base Symbol**	**Base Quantity**	**Typical Symbol**	**Formal Definition**	**Equation**
Second	s	Time	t	The second, symbol s, is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency, $\Delta\nu_{\mathrm{Cs}}$, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be $9\ 192\ 631\ 770$ when expressed in the unit Hz, which is equal to s^{-1}.	$1\ \mathrm{s} = \dfrac{9\ 192\ 631\ 770}{\Delta\nu_{\mathrm{Cs}}}$
Metre	m	Length	$\mathrm{l, x, r,}$ etc.	The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum, c, to be $299\ 792\ 458$ when expressed in the unit $\mathrm{m\ s^{-1}}$, where the second is defined in terms of the caesium frequency $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{m} = \left(\dfrac{\mathrm{c}}{299\ 792\ 458}\right)\mathrm{s}$
Kilogram	kg	Mass	m	The kilogram, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant, h, to be $6.626\ 070\ 15 \times 10^{-34}$ when expressed in the unit $\mathrm{J\ s}$, which is equal to $\mathrm{kg\ m^2\ s^{-1}}$, where the metre and the second are defined in terms of c and $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{kg} = \left(\dfrac{\mathrm{h}}{6.626\ 070\ 15 \times 10^{-34}}\right)\mathrm{m^{-2}s}$
Ampere	A	Electric Current	$\mathrm{I, i}$	The ampere, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge, e, to be $1.602\ 176\ 634 \times 10^{-19}$ when expressed in the unit C, which is equal to $\mathrm{A\ s}$, where the second is defined in terms of $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{A} = \left(\dfrac{\mathrm{e}}{1.602\ 176\ 634 \times 10^{-19}}\right)\mathrm{s^{-1}}$
Kelvin	K	Thermodynamic Temperature	T	The kelvin, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant, k, to be $1.380\ 649 \times 10^{-23}$ when expressed in the unit $\mathrm{J\ K^{-1}}$, which is equal to $\mathrm{kg\ m^2\ s^{-2}}$	$1\ \mathrm{K} = \left(\dfrac{1.380\ 649 \times 10^{-23}}{\mathrm{k}}\right)\mathrm{kg\ m^2\ s^{-2}}$

Base Unit	Base Symbol	Base Quantity	Typical Symbol	Formal Definition	Equation
				$\mathrm{K^{-1}}$, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{\mathrm{Cs}}$.	
Mole	mol	Amount of Substance	n	The mole, symbol mol, is the SI unit of amount of substance. One mole contains exactly $6.022\ 140\ 76 \times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, $\mathrm{N_A}$, when expressed in the unit $\mathrm{mol^{-1}}$ and is called the Avogadro number. The amount of substance, symbol n, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.	$1\ \mathrm{mol} = \left(\frac{6.022\ 140\ 76 \times 10^{23}}{\mathrm{N_A}}\right)$
Candela	cd	Luminous Intensity	$\mathrm{I_V}$	The candela, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency $540 \times 10^{12}\ \mathrm{Hz}$, $\mathrm{K_{cd}}$, to be 683 when expressed in the unit $\mathrm{lm\ W^{-1}}$, which is equal to $\mathrm{cd\ sr\ W^{-1}}$, or $\mathrm{cd\ sr\ kg^{-1}}$ $\mathrm{m^{-2}\ s^{3}}$, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{\mathrm{Cs}}$.	$1\ \mathrm{cd} = \left(\frac{\mathrm{K_{cd}}}{683}\right) \mathrm{kg\ m^2\ s^{-3}\ sr^{-1}}$

Sources:

- Base Unit [1]
- Base Symbol [1]
- Base Quantity [1]
- Typical Symbol [1]
- Formal Definition [1]
- Equation [1]

Derived Units

Derived Unit	**Unit Symbol**	**Derived Quantity**	**Equation Expressed in Terms of SI Base Units**	**Equation Expressed in Terms of Other SI Units**
Radian	rad	Plane Angle	$\mathrm{rad} = \mathrm{m/m}$	-
Steradian	sr	Solid Angle	$\mathrm{sr} = \mathrm{m^2/m^2}$	-
Hertz	Hz	Frequency	$\mathrm{Hz} = \mathrm{s^{-1}}$	-
Newton	N	Force	$\mathrm{N} = \mathrm{kg\,m\,s^{-2}}$	-
Pascal	Pa	Pressure, Stress	$\mathrm{Pa} = \mathrm{kg\,m^{-1}\,s^{-2}}$	-
Joule	J	Energy, Work, Amount of Heat	$\mathrm{J} = \mathrm{kg\,m^2\,s^{-2}}$	$\mathrm{J} = \mathrm{N\,m}$
Watt	W	Power, Radiant Flux	$\mathrm{W} = \mathrm{kg\,m^2\,s^{-3}}$	$\mathrm{W} = \mathrm{J/s}$
Coulomb	C	Electric Charge	$\mathrm{C} = \mathrm{A\,s}$	-
Volt	V	Electric Potential Difference	$\mathrm{V} = \mathrm{kg\,m^2\,s^{-3}\,A^{-1}}$	$\mathrm{V} = \mathrm{W/A}$
Farad	F	Capacitance	$\mathrm{F} = \mathrm{kg^{-1}\,m^{-2}\,s^4\,A^2}$	$\mathrm{F} = \mathrm{C/V}$
Ohm	Ω	Electric Resistance	$\Omega = \mathrm{kg\,m^2\,s^{-3}\,A^{-2}}$	$\Omega = \mathrm{V/A}$
Siemens	S	Electric Conductance	$\mathrm{S} = \mathrm{kg^{-1}\,m^{-2}\,s^3\,A^2}$	$\mathrm{S} = \mathrm{A/V}$
Weber	Wb	Magnetic Flux	$\mathrm{Wb} = \mathrm{kg\,m^2\,s^{-2}\,A^{-1}}$	$\mathrm{Wb} = \mathrm{V\,s}$
Tesla	T	Magnetic Flux Density	$\mathrm{T} = \mathrm{kg\,s^{-2}\,A^{-1}}$	$\mathrm{T} = \mathrm{Wb/m^2}$
Henry	H	Inductance	$\mathrm{H} = \mathrm{kg\,m^2\,s^{-2}\,A^{-2}}$	$\mathrm{H} = \mathrm{Wb/A}$

Derived Unit	**Unit Symbol**	**Derived Quantity**	**Equation Expressed in Terms of SI Base Units**	**Equation Expressed in Terms of Other SI Units**
Degree Celsius	$^\circ\mathrm{C}$	Celsius Temperature	$^\circ\mathrm{C} = \mathrm{K}$, where $-273.15\ ^\circ\mathrm{C} = 0\ \mathrm{K}$	-
Lumen	lm	Luminous Flux	$\mathrm{lm} = \mathrm{cd\ sr}$	$\mathrm{lm} = \mathrm{cd\ sr}$
Lux	lx	Illuminance	$\mathrm{lx} = \mathrm{cd\ sr\ m^{-2}}$	$\mathrm{lx} = \mathrm{lm/m^2}$
Becquerel	Bq	Activity Referred to a Radionuclide	$\mathrm{Bq} = \mathrm{s^{-1}}$	-
Gray	Gy	Absorbed Dose, Kerma	$\mathrm{Gy} = \mathrm{m^2\ s^{-2}}$	$\mathrm{Gy} = \mathrm{J/kg}$
Sievert	Sv	Dose Equivalent	$\mathrm{Sv} = \mathrm{m^2\ s^{-2}}$	$\mathrm{Sv} = \mathrm{J/kg}$
Katal	kat	Catalytic Activity	$\mathrm{kat} = \mathrm{mol\ s^{-1}}$	-

Sources:

- Derived Unit [2]
- Unit Symbol [2]
- Derived Quantity [2]
- Equation Expressed in Terms of SI Base Units [2]
- Equation Expressed in Terms of Other SI Units [2]

SI DEFINING PHYSICAL CONSTANTS (D7)

Defining Constant	**Symbol**	**Numerical Value**	**Unit**
Hyperfine Transition Frequency of Cs	Δv_{Cs}	$9\ 192\ 631\ 770$	Hz
Speed of Light in Vacuum	c	$299\ 792\ 458$	$m\ s^{-1}$
Planck Constant	h	$6.626\ 070\ 15 \times 10^{-34}$	$J\ s$
Elementary Charge	e	$1.602\ 176\ 634 \times 10^{-19}$	C
Boltzmann Constant	k	$1.380\ 649 \times 10^{-23}$	$J\ K^{-1}$
Avogadro Constant	N_A	$6.022\ 140\ 76 \times 10^{23}$	mol^{-1}
Luminous Efficacy	K_{cd}	683	$lm\ W^{-1}$

Sources:

- Defining Constant [1]
- Symbol [1]
- Numerical Value [1]
- Unit [1]

RADIOACTIVE DECAY MODES (D8)

Decay Mode	Symbol	Equation	Nucleus Changes
Alpha Emission	α	${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}\alpha$	$(A-4, Z-2)$
Proton Emission ***2-Proton Emission***	p $2p$	${}^{A}_{Z}X \rightarrow {}^{A-1}_{Z-1}X + {}^{1}_{1}p$ ${}^{A}_{Z}X \rightarrow {}^{A-2}_{Z-2}X + 2\,{}^{1}_{1}p$	$(A-1, Z-1)$ $(A-2, Z-2)$
Neutron Emission ***2-Neutron Emission***	n $2n$	${}^{A}_{Z}X \rightarrow {}^{A-1}{}_{Z}X + {}^{1}_{0}n$ ${}^{A}_{Z}X \rightarrow {}^{A-2}{}_{Z}X + 2\,{}^{1}_{0}n$	$(A-1, Z)$ $(A-2, Z)$
Electron Capture	ε	${}^{A}_{Z}X + {}_{-1}^{0}e \rightarrow {}_{Z-1}{}^{A}X + {}^{0}_{0}\nu_e$	$(A, Z-1)$
Positron Emission	e^+	${}^{A}_{Z}X \rightarrow {}_{Z-1}{}^{A}X + {}_{+1}^{0}e + {}^{0}_{0}\nu_e$	$(A, Z-1)$
Beta-Plus Decay	β^+	$\beta^+ = \varepsilon + e^+$ (Combined rate of ε and e^+)	Variable
Beta-Minus Decay	β^-	${}^{A}_{Z}X \rightarrow {}_{Z+1}{}^{A}X + {}_{-1}^{0}e + {}^{0}_{0}\overline{\nu}_e$	$(A, Z+1)$
Double Beta-Minus Decay	$2\beta^-$	${}^{A}_{Z}X \rightarrow {}_{Z+2}{}^{A}X + 2\,{}_{-1}^{0}e + 2\,{}^{0}_{0}\overline{\nu}_e$	$(A, Z+2)$
Double Beta-Plus Decay	$2\beta^+$	${}^{A}_{Z}X \rightarrow {}_{Z-2}{}^{A}X + 2\,{}_{+1}^{0}e + 2\,{}^{0}_{0}\nu_e$	$(A, Z-2)$
Beta-Minus-Delayed Neutron Emission	$\beta^- n$	${}^{A}_{Z}X \rightarrow {}_{Z+1}{}^{A}X + {}_{-1}^{0}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}{}^{A}X \rightarrow {}^{A-1}_{Z+1}X + {}^{1}_{0}n$	$(A-1, Z+1)$
Beta-Minus-Delayed 2-Neutron Emission	$\beta^- 2n$	${}^{A}_{Z}X \rightarrow {}_{Z+1}{}^{A}X + {}_{-1}^{0}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}{}^{A}X \rightarrow {}^{A-1}_{Z+1}X + 2\,{}^{1}_{0}n$	$(A-2, Z+1)$
Beta-Minus-Delayed 3-Neutron Emission	$\beta^- 3n$	${}^{A}_{Z}X \rightarrow {}_{Z+1}{}^{A}X + {}_{-1}^{0}e + {}^{0}_{0}\overline{\nu}_e$ ${}_{Z+1}{}^{A}X \rightarrow {}^{A-1}_{Z+1}X + 3\,{}^{1}_{0}n$	$(A-3, Z+1)$
Beta-Plus-Delayed Proton Emission	$\beta^+ p$	${}^{A}_{Z}X \rightarrow {}_{Z-1}{}^{A}X + {}_{+1}^{0}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}{}^{A}X \rightarrow {}^{A-1}_{Z-2}X + {}^{1}_{1}p$	$(A-1, Z-2)$
Beta-Plus-Delayed 2-Proton Emission	$\beta^+ 2p$	${}^{A}_{Z}X \rightarrow {}_{Z-1}{}^{A}X + {}_{+1}^{0}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}{}^{A}X \rightarrow {}^{A-2}_{Z-3}X + 2\,{}^{1}_{1}p$	$(A-2, Z-3)$
Beta-Plus-Delayed 3-Proton Emission	$\beta^+ 3p$	${}^{A}_{Z}X \rightarrow {}_{Z-1}{}^{A}X + {}_{+1}^{0}e + {}^{0}_{0}\nu_e$ ${}_{Z-1}{}^{A}X \rightarrow {}^{A-3}_{Z-4}X + 3\,{}^{1}_{1}p$	$(A-3, Z-4)$

Decay Mode	Symbol	Equation	Nucleus Changes
Beta-Minus-Delayed Alpha Emission	$\beta^{-}\alpha$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_{e}$ ${}_{Z+1}^{A}X \rightarrow {}_{Z-1}^{A-4}X + {}_{2}^{4}\alpha$	$(A-4, Z-1)$
Beta-Plus-Delayed Alpha Emission	$\beta^{+}\alpha$	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}_{+1}^{0}e + {}_{0}^{0}\nu_{e}$ ${}_{Z-1}^{A}X \rightarrow {}_{Z-3}^{A-4}X + {}_{2}^{4}\alpha$	$(A-4, Z-3)$
Beta-Minus-Delayed Deuteron Emission	$\beta^{-}d$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_{e}$ ${}_{Z+1}^{A}X \rightarrow {}^{A-2}_{Z}X + {}_{1}^{2}d$	$(A-2, Z)$
Beta-Minus-Delayed Triton Emission	$\beta^{-}t$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_{e}$ ${}_{Z+1}^{A}X \rightarrow {}^{A-3}_{Z}X + {}_{1}^{3}t$	$(A-3, Z)$
Internal (Isomeric) Transition	IT	${}^{Am}_{Z}X \rightarrow {}^{A}_{Z}X + {}_{0}^{0}\gamma$	(A, Z)
Spontaneous Fission	SF	Variable	Variable
Beta-Plus-Delayed Fission	$\beta^{+}SF$	${}^{A}_{Z}X \rightarrow {}_{Z-1}^{A}X + {}_{+1}^{0}e + {}_{0}^{0}\nu_{e}$ Variable	Variable
Beta-Minus-Delayed Fission	$\beta^{-}\,SF$	${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}X + {}_{-1}^{0}e + {}_{0}^{0}\overline{\nu}_{e}$ Variable	Variable
Heavy Cluster Emission **Cluster Decay**	${}^{A}X$ CD	Variable	Variable

Sources:

- Decay Mode [1]
- Symbol [1] [2]
- Equation[2] [3]
- Nucleus Changes [2] [3]

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D2 – Properties of Elements

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