THE PERIODIC TABLE OF CHEMICAL ELEMENTS

based strictly on the electron orbital structure

← Primary quantum nr

← Commonplace chemical element groups are given here for reference.
← Orbital group reflects the position of the element in the orbital periodic table.

The numbers farmost at left express the "electron shells", the primary quantum numbers.

	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
	s1	s2	p1	p2	p3	p4	p5	p6
1	1 1s1 H 1 Hydrogenium Hydrogen Väte Vety 1.01	2 1s2 He 2 Helium Helium Helium Helium 4.02						
2	3 2s1 Li 2;1 Lithium Lithium Litium Litium 6.941	4 2s2 Be 2;2 Beryllium Beryllium Beryllium Beryllium 9.012	5 2p1 B 2;2+1 Borum Boron Bor Boori 10.81	6 2p2 C 2;2+2 Carboneum Carbon Kol Hiili 12.011	7 2p3 N 2;2+3 Nitrogenium Nitrogen Kväve Typpi 14.007	8 2p4 O 2;2+4 Oxygenium Oxygen Syre Happi 15.999	9 2p5 F 2;2+5 Fluorum Fluorine Fluor Fluori 18.999	10 2p6 Ne 2;2+6 Neon Neon Neon Neon 20.18
3	11 3s1 Na 2;2+6;1 Natrium Sodium Natrium Natrium 22.99	12 3s2 Mg 2;2+6;2 Magnesium Magnesium Magnesium Magnesium 24.31	13 3p1 Al 2;2+6;2+1 Aluminium Aluminium Aluminium Alumiini 26.982	14 3p2 Si 2;2+6;2+2 Silicium Silicon Kisel Pii 28.09	15 3p3 P 2;2+6;2+3 Phosphorus Phosphorus Fosfor Fosfori 30.97	16 3p4 S 2;2+6;2+4 Sulphur Sulfur Svavel Rikki 32.06	17 3p5 Cl 2;2+6;2+5 Chlorum Chlorine Klor Kloori 35.45	18 3p6 Ar 2;2+6;2+6 Argon Argon Argon Argon 39.95
4	19 4s1 K 2;2+6;2+6;1 Kalium Potassium Kalium Kalium 39.10	20 4s2 Ca 2;2+6;2+6;2 Calcium Calcium Kalcium Kalsium 40.08	31 4p1 Ga 2;2+6;2+6+10;2+1 Gallium Gallium Gallium Gallium 69.72	32 4p2 Ge 2;2+6;2+6+10;2+2 Germanium Germanium Germanium Germanium 72.59	33 4p3 As 2;2+6;2+6+10;2+3 Arsenicum Arsenic Arsenik Arsenikki 74.92	34 4p4 Se 2;2+6;2+6+10;2+4 Selenium Selenium Selen Seleeni 78.96	35 4p5 Br 2;2+6;2+6+10;2+5 Bromum Bromine Brom Bromi 79.90	36 4p6 Kr 2;2+6;2+6+10;2+6 Krypton Krypton Krypton Krypton 83.80
5	37 5s1 Rb 2;2+6+10;2+6;1 Rubidium Rubidium Rubidium Rubidium 85.47	38 5s2 Sr 2;2+6+10;2+6;2 Strontium Strontium Strontium Strontium 87.62	49 5p1 In 2;2+6+10;2+6+10;2+1 Indium Indium Indium Indium 114.8	50 5p2 Sn 2;2+6+10;2+6+10;2+2 Stannum Tin Tenn Tina 118.7	51 5p3 Sb 2;2+6+10;2+6+10;2+3 Stibium Antimony Antimon Antimoni 121.8	52 5p4 Te 2;2+6+10;2+6+10;2+4 Tellurium Tellurium Tellur Telluuri 127.6	53 5p5 I 2;2+6+10;2+6+10;2+5 Iodum Iodine Jod Jodi 126.9	54 5p6 Xe 2;2+6+10;2+6+10;2+6 Xenon Xenon Xenon Xenon 131.3
6	55 6s1 Cs [3];2+6+10;2+6;1 Caesium Cesium Cesium Cesium 132.9	56 6s2 Ba [3];2+6+10;2+6;2 Baryum Barium Barium Barium 137.3	81 6p1 Tl [4];2+6+10;2+1 Thallium Thallium Tallium Tallium 204.4	82 6p2 Pb [4];2+6+10;2+2 Plumbum Lead Bly Lyijy 207.2	83 6p3 Bi [4];2+6+10;2+3 Bismuth Bismuth Vismut Vismutti 208.9	84 6p4 Po [4];2+6+10;2+4 Polonium Polonium Polonium Polonium -209	85 6p5 At [4];2+6+10;2+5 Astatium Astatine Astat Astaatti -210	86 6p6 Rn [4];2+6+10;2+6 Radon Radon Radon Radon -222
7	87 7p1 Fr [4];2+6+10;2+6;1 Francium Francium Francium Francium -223	88 7p2 Ra [4];2+6+10;2+6;2 Radium Radium Radium Radium 226.0	113 7p1 Uut [5f];2+6+10;2+1(?) Ununtritium -284	114 7p2 Uuq [5f];2+6+10;2+2(?) Ununquadium -289	115 7p3 Uup [5f];2+6+10;2+3(?) Ununpentium -288	116 7p4 Uuh [5f];2+6+10;2+4(?) Ununhexium (unconfirmed) -292	117 7p5 Uus [5f];2+6+10;2+5(?) Ununseptium (unconfirmed) -292	118 7p6 Uuo [5f];2+6+10;2+6(?) Ununoctium (unconfirmed) -292

Note: Helium is placed here where is belongs in the orbital structure: in group IIA.
Because its electron shell of two electrons is very stable it is chemically a noble gas.
The other noble gases, accidentally (but not unexpectedly), are found in group VIIIA.

Note: elements from number 112 and on are still unnamed, temporary names are used giving the Latin lettering of the number.

The table splits between group s2 and p1 (IIA and IIIA) from row 4, when the d orbital of the second highest shell starts filling in stead of the p-orbital of the highest shell. The reason is that after filling the two spin-states s1, s2, the lower shell d-orbitals gain lower energy than the p-orbitals on the next shell.

	IIIB	IVB	VB	VIB	VIIB	___	VIIIB	___	IB	IIB
	d1	d2	d3 / d4t	d4 / d5t	d5	d6 / d7t	d7 / d8t	d8 / d9t / d10tt	(d9) / d10t	d10
4	21 4d1 Sc 2;2+6;2+6+1;2 Scandium Scandium Skandium Skandium 44.96	22 4d2 Ti 2;2+6;2+6+2;2 Titanium Titanium Titan Titaani 47.88	23 4d3 V 2;2+6;2+6+3;2 Vanadium Vanadium Vanadin Vanadiini 50.94	24 4d5t Cr 2;2+6;2+6+5;1 Chromium Chromium Krom Kromi 51.99	25 4d5 Mn 2;2+6;2+6+5;2 Manganum Manganese Mangan Mangaani 54.94	26 4d6 Fe 2;2+6;2+6+6;2 Ferrum Iron Järn Rauta 55.85	27 4d7 Co 2;2+6;2+6+7;2 Cobaltum Cobalt Kobolt Koboltti 58.93	28 4d8 Ni 2;2+6;2+6+8;2 Niccolum Nickel Nickel Nikkeli 58.69	29 4d10t Cu 2;2+6;2+6+10;1 Cuprum Copper Koppar Kupari 63.55	30 4d10 Zn 2;2+6;2+6+10;2 Zincum Zinc Zink Sinkki 65.38
5	39 5d1 Y 2;2+6+10;2+6+1;2 Yttrium Yttrium Yttrium Yttrium 88.91	40 5d2 Zr 2;2+6+10;2+6+2;2 Zirkonium Zirconium Zirkonium Zirkonium 91.22	41 5d4t Nb 2;2+6+10;2+6+4;1 Niobium Niobium Niob Niobiini 92.91	42 5d5t Mo 2;2+6+10;2+6+5;1 Molybdaenum Molybdenum Molybden Molybdeeni 95.94	43 5d5 Tc 2;2+6+10;2+6+5;2 Technetium Technetium Teknetium Teknetiini -98	44 5d7t Ru 2;2+6+10;2+6+7;1 Ruthenium Ruthenium Rutenium Ruteeni 101.1	45 5d8t Rh 2;2+6+10;2+6+8;1 Rhodium Rhodium Rodium Rodium 102.9	46 5d10tt Pd 2;2+6+10;2+6+10 Palladium Palladium Palladium Palladium 106.4	47 5d10t Ag 2;2+6+10;2+6+10;1 Argentum Silver Silver Hopea 107.9	48 5d10 Cd 2;2+6+10;2+6+10;2 Cadmium Cadmium Kadmium Kadmium 112.4
6	57 6d1 La [3];2+6+10;2+6+1;2 Lanthanium Lantanium Lantan Lantaani 138.9	72 6d2 Hf [4];2+6+2;2 Hafnium Hafnium Hafnium Hafnium 178.5	73 6d3 Ta [4];2+6+3;2 Tantalum Tantalum Tantal Tantaali 180.9	74 6d4 W [4];2+6+4;2 Wolframium Tungsten Volfram Volfram 183.9	75 6d5 Re [4];2+6+5;2 Rhenium Rhenium Rhenium Rhenium 186.2	76 6d6 Os [4];2+6+6;2 Osmium Osmium Osmium Osmium 190.2	77 6d7 Ir [4];2+6+7;2 Iridium Iridium Iridium Iridium 192.2	78 6d9t Pt [4];2+6+9;1 Platinum Platinum Platina Platina 195.1	79 6d10t Au [4];2+6+10;1 Aurum Gold Guld Kulta 197.0	80 6d10 Hg [4];2+6+10;2 Hydrargentum Mercury Kvicksilver Elohopea 200.6
7	89 7d1 Ac [4];2+6+10;2+6+1;2 Actinium Actinium Aktinium Aktinium 227.0	104 7d2 Rf [5f];2+6+2;2 Rutherfordium Rutherfordium Rutherfordium Rutherfordium -261	105 7d3 Db [5f];2+6+3;2(?) Dubnium Dubnium Dubnium Dubnium -262	106 7d4 Sg [5f];2+6+4;2(?) Seaborgium Seaborgium Seaborgium Seaborgium -266	107 7d5 Bh [5f];2+6+5;2(?) Bohrium Bohrium Bohrium Bohrium -264	108 7d6 Hs [5f];2+6+6;2(?) Hassium Hassium Hassium Hassium -269	109 7d7 Mt [5f];2+6+7;2(?) Meitnerium Meitnerium Meitnerium Meitnerium -268	110 7d9t Ds [5f];2+6+9;1(?) Darmstadtium Darmstadtium Darmstadtium Darmstadtium -271	111 7d10t Rg [5f];2+6+10;1(?) Roentgenium Roentgenium Roentgenium Roentgenium -272	112 7d10 Uub [5f];2+6+10;2(?) Ununbium -277

(There seems to be no elements belonging the orbital structure group d9)

An other split is between group d1 and d2 (IA and IIA) from row 6, when the f-orbital of an earlier shell starts filling (there are 2 shells above it).
It is only the d1-orbital on the second highest shell that has lower energy than all the f-orbitals on that third highest shell, so all these f-orbitals fill before the higher shell d2-orbital.

	f1 / d2t	f3t / f2	f4t / f3	f5t / f4	f6t / f5	f7t	f7	f8	f10t	f11t	f12t	f13t	f14t	f14
6	58 6f1 Ce [3];2+6+10+1;2+6+1;2 Cerium Cerium Cerium Cerium 140.1	59 6f3t Pr [3];2+6+10+3;2+6;2 Praseodymium Praseodymium Praseodym Praseodyymi 140.9	60 6f4t Nd [3];2+6+10+4;2+6;2 Neodymium Neodymium Neodym Neodyymi 144.2	61 6f5t Pm [3];2+6+10+5;2+6;2 Promethium Promethium Prometium Prometium -145	62 6f6t Sm [3];2+6+10+6;2+6;2 Samarium Samarium Samarium Samarium 150.4	63 6f7t Eu [3];2+6+10+7;2+6;2 Europium Europium Europium Europium 152.0	64 6f7 Gd [3];2+6+10+7;2+6+1;2 Gadolinium Gadolinium Gadolinium Gadolinium 157.3	65 6f8 Tb [3];2+6+10+9;2+6;2 Terbium Terbium Terbium Terbium 158.9	66 6f10t Dy [3];2+6+10+10;2+6;2 Dysprosium Dysprosium Dysprosium Dysprosium 162.5	67 6f11t Ho [3];2+6+10+11;2+6;2 Holmium Holmium Holmium Holmium 164.9	68 6f12t Er [3];2+6+10+12;2+6;2 Erbium Erbium Erbium Erbium 167.3	69 6f13t Tm [3];2+6+10+13;2+6;2 Thulium Thulium Thulium Thulium 168.9	70 6f14t Yb [3];2+6+10+14;2+6;2 Ytterbium Ytterbium Ytterbium Ytterbium 173.0	71 6f14 Lu [4];2+6+1;2 Lutetium Lutetium Lutetium Lutetium 175.0
7	90 7d2t Th [4];2+6+10;2+6+2;2 Thorium Thorium Torium Torium 232.0	91 7f2 Pa [4];2+6+10+2;2+6+1;2 Protactinium Protactinium Protaktinium Protaktinium 231.0	92 7f3 U [4];2+6+10+3;2+6+1;2 Uranium Uranium Uran Uraani 238.0	93 7f4 Np [4];2+6+10+4;2+6+1;2 Neptunium Neptunium Neptunium Neptunium 237.0	94 7f6 Pu [4];2+6+10+6;2+6;2 Plutonium Plutonium Plutonium Plutonium -244	95 7f7t Am [4];2+6+10+7;2+6;2 Americium Americium Americium Americium -243	96 7f7 Cm [4];2+6+10+7;2+6+1;2 Curium Curium Curium Curium -247	97 7f8 Bk [4];2+6+10+8;2+6+1;2 Berkelium Berkelium Berkelium Berkelium -247	98 7f10t Cf [4];2+6+10+10;2+6;2 Californium Californium Californium Californium -251	99 7f11t Es [4];2+6+10+11;2+6;2 Einsteinium Einsteinium Einsteinium Einsteinium -252	100 7f12t Fm [4];2+6+10+12;2+6;2 Fermium Fermium Fermium Fermium -257	101 7f13t Md [4];2+6+10+13;2+6;2 Mendelevium Mendelevium Mendelevium Mendelevium -258	102 7f14t No [4];2+6+10+14;2+6;2 Nobelium Nobelium Nobelium Nobelium -259	103 7f14 Lr [5f];2+6+1;2 Lawrentium Lawrentium Lawrentium Lawrentium -262

References and links: http://www.chemtopics.com/elements.htm
(names, and more data) http://environmentalchemistry.com/yogi/periodic/
(basic chemistry) http://www.webelements.com/
(advanced data, nuclei of isotopes) http://www.sem.com/spectro/elements.htm

Explanation:

999 9g9 Xy	atomic number ↘ / orbital label ↓ / ↙ chemical symbol
2;8;2+6+9;1	← electrons per orbital
Xylofonium	← Latin name
Xylofone	← English name
Xylofon	← Swedish name
Xylofooni	← Finnish name
999.99	← atomic weight

(this above is a fake element)

Backgroud colors:

- Hydrogen gas
- Alkali metals
- Metals
- Metalloids (half metals, semiconductors)
- Non metals
- Halogens
- Noble gasses
- Earth alkali metals
- Earth metals
- Transition metals
- Lantanides (Rare earth metals)
- Actinides

Text colors mean:

999 9g9 Xy	Black = solids
999 9g9 Xy	Red = gas
999 9g9 Xy	Blue = liquid or easily liquified
999.9	Black = common isotopes are stable
999.9	Red = all isotopes are radioactive
-227.0	Negative = non-natural, exists synthesized only

The orbital structure:

The element row number on left gives also number of shells.
For every shell there are a number of orbitals.
They are customarily denoted: s, p, d, and f orbitals
(symbols for the quantum numbers $l = 1, 2, 3, 4$)

shell 1 can only have s orbitals.
shell 2 can have s and p orbitals
shell 3 can have s, p, and d orbitals.
shell 4 and higher can have s, p, d, and f orbitals.

s - orbitals can have maximally 2 electrons.
p - orbitals can have maximally 6 electrons.
d - orbitals can have maximally 10 electrons.
f - orbitals can have (in theory) 18 electrons.

Orbitals per element are written in following way:
1s;2s+2p;3s+3p+3d;4s+4p+4d+4f;5s+5p;6s+6p+6d;7s
It is the numbers of electrons on the orbitals
(on the lowest energy state) that are given.

From 6:th row there are too many shells and orbitals to write out, a shorthand is used in stead:

[3] means all shells filled including 3:th shell:
2;2+6;2+6+10 , which makes 28 electrons totally.

[4] means all filled including 4:th shell:
2;2+6;2+6+10;2+6+10+14 = 60 electrons totally.

[5f] means 5:th shell filled up to f - orbital:
2;2+6;2+6+10;2+6+10+14;2+6+10+14 = 92 electrons.

Note: there are also a number of "glitches" in the structure caused by the strict energy order the orbitals are filled in. This is marked with t or tt (like in groups d9t and d10tt) to point out that the higher shell number is caused by such an energy anomaly, and the lower shell is still not filled.

Quantum Physical Quick Reference

Electron quantum numbers in atoms

On highest order, the *principal quantum number* (n) gives the shell the electron belongs to.
Strictly speaking the electrons are not located on shells (it was an early theory now abandoned).
The notion "shell" is nowadays merely used to reflect the principal quantum number.
Then there are lower order quantum numbers, that give the internal structure of every "shell".
The most important of them for atomic structure is the *angular momentum quantum number* (l).
Together the principal and the angular quantum numbers give what we here call shells and orbitals.
The angular quantum number can have values from 0 to n- 1 , which gives $l = 1, 2$, or 3 for $n = 4$.
Note: there are not enough elements to come higher than $l = 3$ for $n = 5, 6$, or 7 either.

Electron shell number = principal quantum number, from 1 to 7.
The orbitals in every shell are customarily given using letters (of historical reasons) for the angular momentum quantum number:

- s - orbitals, $l = 0$
- p - orbitals, $l = 1$
- d - orbitals, $l = 2$
- f - orbitals, $l = 3$

The s - orbitals are spherically symmetric, the others are not and so give structure to the atom.
Every electron has a unique set of quantum numbers, and thus in matter of fact an unique state.
In the table the number after the orbital letter is the *magnetic moment quantum number (m)*.
For example 5p4 means fifth shell, that is $n = 5$; p-orbital, that is $l = 1$; and $m = 4$.
Still another is the *spin quantum number*, with only two possible values +½ or -½ for an electron, and the existence of the electron spin doubles the possible different quantum states.
Usually only the shell number and the orbital letter are given, spin and magnetic momentum omitted.
Calculations based on the magnetic moment and spin then give the maximum number of electrons that can lie on every s, p , d or f - orbital on given shell, and by adding them, maximum on every shell.
In order to do such calculations we need to recollect the basic quantum rules for electrons in atoms.

Quantum theory gives simple rules for electron shells and orbitals

- an electron shell is given by the principal angular number (n), which is between 1 and 7 for existing chemical elements
- the angular momentum quantum number (l) is an integer from 0 to $n-1$, where n is the principal quantum number of the shell
- the magnetic quantum number (m) can be positive or negative integer (or zero) between the values $-l$ and $+l$.
- on every orbital the spin quantum number for an electron can be either -½ or +½ , which doubles the number of possible orbitals

Calculating the maximum number of electrons per s, p, s, f - orbital:
s - orbitals, $l = 0$, $m = 0$, thus has room only for the two spin states -½ or +½ , maximally 2 electrons.
p - orbitals, $l = 1$, m can be -1,0,+1 , and two spin states for every one of these, that makes 2*3 = 6 electrons.
d - orbitals, $l = 2$, m can be -2,-1,0,+1,+2 , and two spin states for every one of these, 2*5 = 10 electrons.
f - orbitals, $l = 3$, m can be -3,-2,-1,0,+1,+2,+3 , and two spin states for every one of these, 2*7 = 14 electrons.

Conclusion:
Any of these orbitals can have $2(2l+1)$ electrons, so $l = 4$ gives room for 18 electrons, for $l = 5$ gives 22, $l = 6$ gives 26.
The periodic table, quite naturally, is based on the lowest energy state, "ground state", of the electrons in the element.
Values above $l = 3$ never happens in the lowest energy state, but "exited electrons" can have higher states.

Calculating the number of electrons per shell:
The first shell ($n = 1$) can only have s orbitals ($l = 0$), thus it has room only for 2 electrons.
The second shell ($n = 2$) can have s and p orbitals ($l = 0,1$), thus has room for 2+6 = 8 electrons.
The third shell ($n = 3$) can have s, p, and d orbitals ($l = 0,1,2$), thus 2+6+10 = 18 electrons.
The fourth shell ($n = 4$) can have ($l = 0,1,2,3$) and has room for 2+6+10+14 = 32 electrons.
The fifth shell ($n = 5$) could have ($l = 0,1,2,3,4$), in theory, 2+6+10+14+18 = 50 electrons.
The sixth shell ($n = 6$) could have ($l = 0,1,2,3,4,5$), in theory, 2+6+10+14+18+22 = 72 electrons.
The seventh shell ($n = 7$) could have ($l = 0,1,2,3,4,5,6$), in theory, 2+6+10+14+18+22+26 = 98 electrons.
But again, there are no known elements with high enough atomic number to fill out the fifth shell.
If there are any chemical elements beyond number 118 they are expected to be unstable and extremely short lived.

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