I) INTRODUÇÃO À ESTRUTURA DA MATÉRIA (ÁTOMOS E MOLÉCULAS)

Tabela Periódica

Composição elementar

Modelos atômicos e distribuição eletrônica

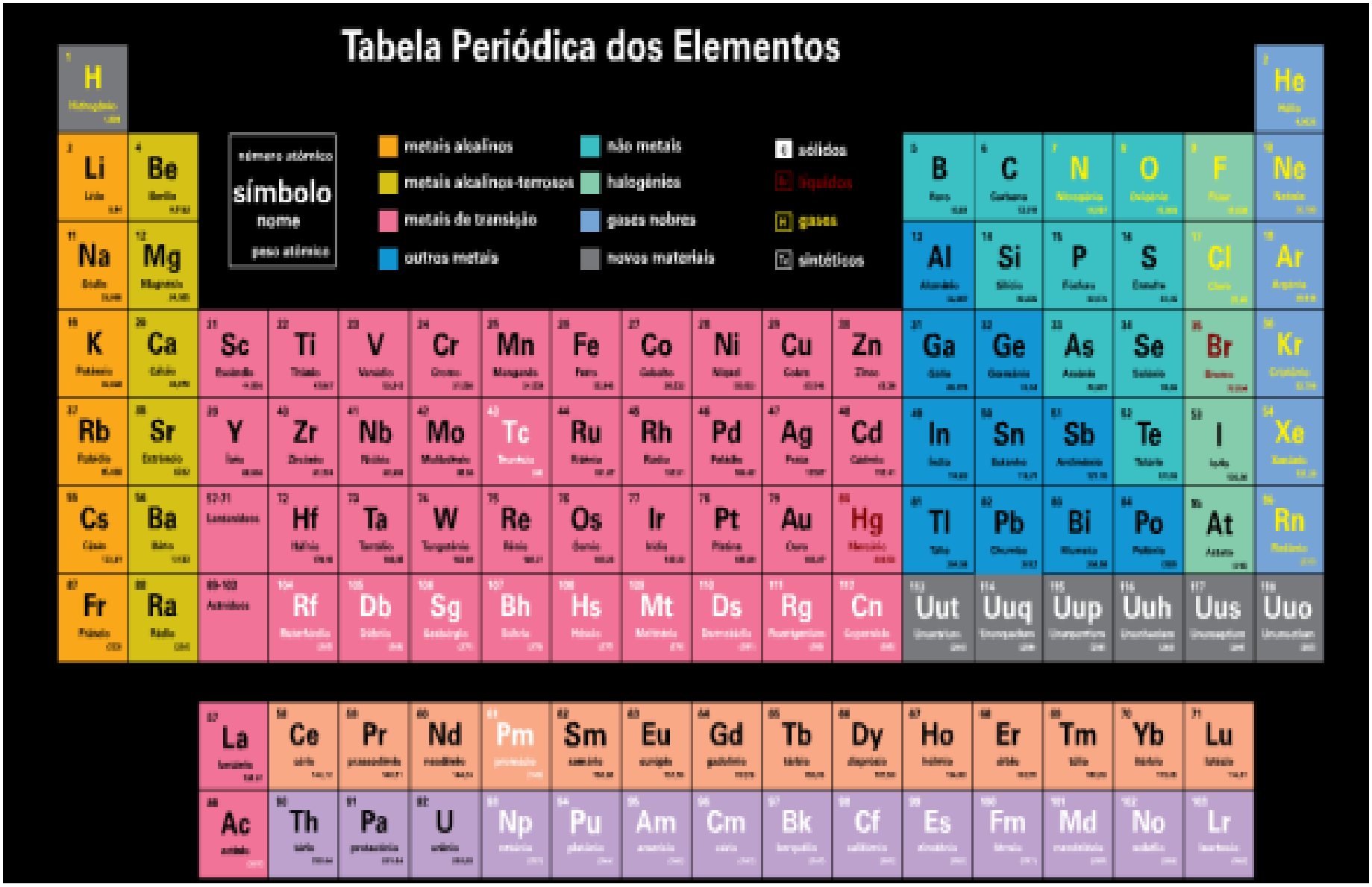
Isótopos

Massa Atômica e Massa Molecular

II) COMPOSTOS COVALENTES E IÔNICOS

CONCEITOS BÁSICOS DE LIGAÇÃO QUÍMICA

ELEMENTOS EM QUÍMICA



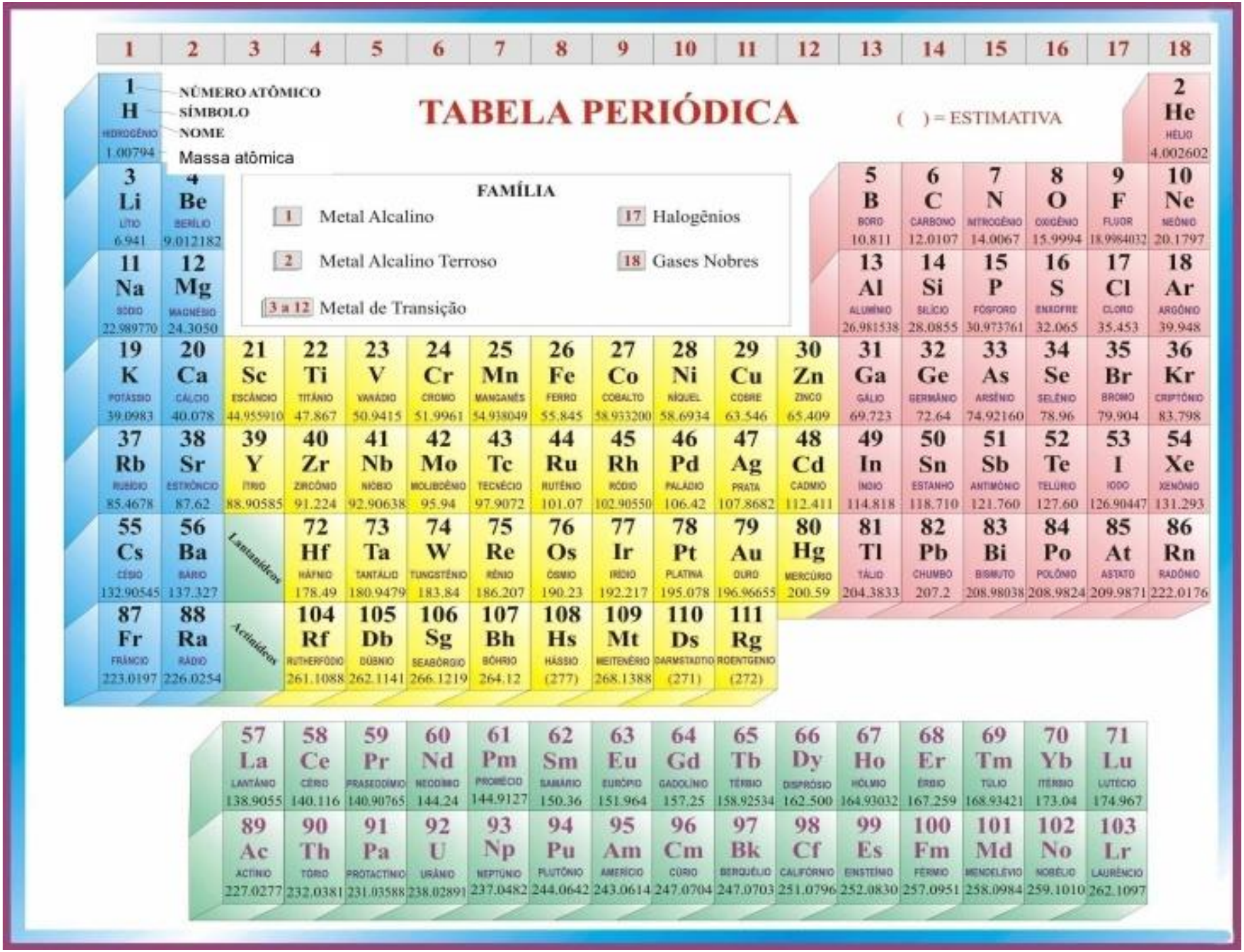


TABELA PERIÓDICA
( ) = ESTIMATIVA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1 H HIDROGÊNIO 1.00794
NÚMERO ATÔMICO
SÍMBOLO
NOME
Massa atômica
2 He HÉLIO 4.002602
3 Li LÍTIO 6.941
4 Be BERÍLIO 9.012182
5 B BORO 10.811
6 C CARBONO 12.0107
7 N NITROGÊNIO 14.0067
8 O OXIGÊNIO 15.9994
9 F FLUOR 18.9984032
10 Ne NEÔNIO 20.1797
11 Na SÓDIO 22.989770
12 Mg MAGNÉSIO 24.3050
13 Al ALUMÍNIO 26.981538
14 Si SILÍCIO 28.0855
15 P FÓSFORO 30.973761
16 S ENXOFRE 32.065
17 Cl CLORO 35.453
18 Ar ARGÔNIO 39.948
19 K POTÁSSIO 39.0983
20 Ca CÁLCIO 40.078
21 Sc ESCÂNDIO 44.955910
22 Ti TITÂNIO 47.867
23 V VANÁDIO 50.9415
24 Cr CROMO 51.9961
25 Mn MANGANÊS 54.938049
26 Fe FERRO 55.845
27 Co COBALTO 58.933200
28 Ni NÍQUEL 58.6934
29 Cu COBRE 63.546
30 Zn ZINCO 65.409
31 Ga GÁLIO 69.723
32 Ge GERMÂNIO 72.64
33 As ARSÊNIO 74.92160
34 Se SELÊNIO 78.96
35 Br BROMO 79.904
36 Kr CRIPTÔNIO 83.798
37 Rb RUBÍDIO 85.4678
38 Sr ESTRÔNCIO 87.62
39 Y ÍTRIO 88.90585
40 Zr ZIRCÔNIO 91.224
41 Nb NIÓBIO 92.90638
42 Mo MOLIBDÊNIO 95.94
43 Tc TECNÉCIO 97.9072
44 Ru RUTÊNIO 101.07
45 Rh RÓDIO 102.90550
46 Pd PALÁDIO 106.42
47 Ag PRATA 107.8682
48 Cd CADMIO 112.411
49 In ÍNDIO 114.818
50 Sn ESTANHO 118.710
51 Sb ANTIMÔNIO 121.760
52 Te TELÚRIO 127.60
53 I IODO 126.90447
54 Xe XENÔNIO 131.293
55 Cs CÉSIO 132.90545
56 Ba BÁRIO 137.327
Lantanídeos
72 Hf HÁFNIO 178.49
73 Ta TÂNTALO 180.9479
74 W TUNGSTÊNIO 183.84
75 Re RÊNIO 186.207
76 Os ÓSMIO 190.23
77 Ir ÍRIDIO 192.217
78 Pt PLATINA 195.078
79 Au OURO 196.96655
80 Hg MERCÚRIO 200.59
81 Tl TÁLIO 204.3833
82 Pb CHUMBO 207.2
83 Bi BISMUTO 208.98038
84 Po POLÔNIO 208.9824
85 At ASTATO 209.9871
86 Rn RADÔNIO 222.0176
87 Fr FRÂNCIO 223.0197
88 Ra RÁDIO 226.0254
Actinídeos
104 Rf RUTHERFÓDIO 261.1088
105 Db DÚBNIO 262.1141
106 Sg SEABÓRGIO 266.1219
107 Bh BÓHRIO 264.12
108 Hs HÁSSIO (277)
109 Mt MEITENÉRIO 268.1388
110 Ds DARMSTADTIO (271)
111 Rg ROENTGENIO (272)
FAMÍLIA
1 Metal Alcalino
2 Metal Alcalino Terroso
3 a 12 Metal de Transição
17 Halogênios
18 Gases Nobres
57 La LANTÂNIO 138.9055
58 Ce CÉRIO 140.116
59 Pr PRASEODÍMIO 140.90765
60 Nd NEODÍMIO 144.24
61 Pm PROMÉCIO 144.9127
62 Sm SAMÁRIO 150.36
63 Eu EURÓPIO 151.964
64 Gd GADOLÍNIO 157.25
65 Tb TÉRBIO 158.92534
66 Dy DISPRÓSIO 162.500
67 Ho HÓLMIO 164.93032
68 Er ÉRBIO 167.259
69 Tm TÚLIO 168.93421
70 Yb ITÉRBIO 173.04
71 Lu LUTÉCIO 174.967
89 Ac ACTÍNIO 227.0277
90 Th TÓRIO 232.0381
91 Pa PROTACTÍNIO 231.03588
92 U URÂNIO 238.02891
93 Np NETÚNIO 237.0482
94 Pu PLUTÔNIO 244.0642
95 Am AMERÍCIO 243.0614
96 Cm CÚRIO 247.0704
97 Bk BERQUÉLIO 247.0703
98 Cf CALIFÓRNIO 251.0796
99 Es EINSTEÍNIO 252.0830
100 Fm FÉRMIO 257.0951
101 Md MENDELÉVIO 258.0984
102 No NOBÉLIO 259.1010
103 Lr LAURÊNCIO 262.1097

PERIODIC TABLE

Atomic Properties of the Elements

NIST National Institute of Standards and Technology
U.S. Department of Commerce

Physical Measurement Laboratory
www.nist.gov/pml

Standard Reference Data
www.nist.gov/srd

Frequently used fundamental physical constants

For the most accurate values of these and other constants, visit physics.nist.gov/constants

1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of ^{133}Cs

speed of light in vacuum	c	299 792 458 m s^{-1}	(exact)
Planck constant	h	6.626 07 x 10^{-34} J s	($\hbar = h/2\pi$)
elementary charge	e	1.602 177 x 10^{-19} C	
electron mass	m_e	9.109 38 x 10^{-31} kg	
	$m_e c^2$	0.510 999 MeV	
proton mass	m_p	1.672 622 x 10^{-27} kg	
fine-structure constant	α	1/137.035 999	
Rydberg constant	R_∞	10 973 731.569 m^{-1}	
	$R_\infty c$	3.289 841 960 x 10^{15} Hz	
	$R_\infty hc$	13.605 69 eV	
Boltzmann constant	k	1.380 6 x 10^{-23} J K^{-1}	

Solids
Liquids
Gases
Artificially Prepared

Group	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
Period 1	1 $^2S_{1/2}$ **H** Hydrogen 1.008* 1s 13.5984																	2 $^1S_0$ **He** Helium 4.002602 $1s^2$ 24.5874
2	3 $^2S_{1/2}$ **Li** Lithium 6.94* $1s^2 2s$ 5.3917	4 $^1S_0$ **Be** Beryllium 9.0121831 $1s^2 2s^2$ 9.3227											5 $^2P^o_{1/2}$ **B** Boron 10.81* $1s^2 2s^2 2p$ 8.2980	6 $^3P_0$ **C** Carbon 12.011* $1s^2 2s^2 2p^2$ 11.2603	7 $^4S^o_{3/2}$ **N** Nitrogen 14.007* $1s^2 2s^2 2p^3$ 14.5341	8 $^3P_2$ **O** Oxygen 15.999* $1s^2 2s^2 2p^4$ 13.6181	9 $^2P^o_{3/2}$ **F** Fluorine 18.99840316 $1s^2 2s^2 2p^5$ 17.4228	10 $^1S_0$ **Ne** Neon 20.1797 $1s^2 2s^2 2p^6$ 21.5645
3	11 $^2S_{1/2}$ **Na** Sodium 22.98976928 [Ne]3s 5.1391	12 $^1S_0$ **Mg** Magnesium 24.305* $[Ne]3s^2$ 7.6462											13 $^2P^o_{1/2}$ **Al** Aluminum 26.9815385 $[Ne]3s^2 3p$ 5.9858	14 $^3P_0$ **Si** Silicon 28.085* $[Ne]3s^2 3p^2$ 8.1517	15 $^4S^o_{3/2}$ **P** Phosphorus 30.97376200 $[Ne]3s^2 3p^3$ 10.4867	16 $^3P_2$ **S** Sulfur 32.06* $[Ne]3s^2 3p^4$ 10.3600	17 $^2P^o_{3/2}$ **Cl** Chlorine 35.45* $[Ne]3s^2 3p^5$ 12.9676	18 $^1S_0$ **Ar** Argon 39.948 $[Ne]3s^2 3p^6$ 15.7596
4	19 $^2S_{1/2}$ **K** Potassium 39.0983 [Ar]4s 4.3407	20 $^1S_0$ **Ca** Calcium 40.078 $[Ar]4s^2$ 6.1132	21 $^2D_{3/2}$ **Sc** Scandium 44.955908 $[Ar]3d4s^2$ 6.5615	22 $^3F_2$ **Ti** Titanium 47.867 $[Ar]3d^2 4s^2$ 6.8281	23 $^4F_{3/2}$ **V** Vanadium 50.9415 $[Ar]3d^3 4s^2$ 6.7462	24 $^7S_3$ **Cr** Chromium 51.9961 $[Ar]3d^5 4s$ 6.7665	25 $^6S_{5/2}$ **Mn** Manganese 54.938044 $[Ar]3d^5 4s^2$ 7.4340	26 $^5D_4$ **Fe** Iron 55.845 $[Ar]3d^6 4s^2$ 7.9025	27 $^4F_{9/2}$ **Co** Cobalt 58.933194 $[Ar]3d^7 4s^2$ 7.8810	28 $^3F_4$ **Ni** Nickel 58.6934 $[Ar]3d^8 4s^2$ 7.6399	29 $^2S_{1/2}$ **Cu** Copper 63.546 $[Ar]3d^{10} 4s$ 7.7264	30 $^1S_0$ **Zn** Zinc 65.38 $[Ar]3d^{10} 4s^2$ 9.3942	31 $^2P^o_{1/2}$ **Ga** Gallium 69.723 $[Ar]3d^{10} 4s^2 4p$ 5.9993	32 $^3P_0$ **Ge** Germanium 72.630 $[Ar]3d^{10} 4s^2 4p^2$ 7.8994	33 $^4S^o_{3/2}$ **As** Arsenic 74.921595 $[Ar]3d^{10} 4s^2 4p^3$ 9.7886	34 $^3P_2$ **Se** Selenium 78.971 $[Ar]3d^{10} 4s^2 4p^4$ 9.7524	35 $^2P^o_{3/2}$ **Br** Bromine 79.904* $[Ar]3d^{10} 4s^2 4p^5$ 11.8138	36 $^1S_0$ **Kr** Krypton 83.798 $[Ar]3d^{10} 4s^2 4p^6$ 13.9996
5	37 $^2S_{1/2}$ **Rb** Rubidium 85.4678 [Kr]5s 4.1771	38 $^1S_0$ **Sr** Strontium 87.62 $[Kr]5s^2$ 5.6949	39 $^2D_{3/2}$ **Y** Yttrium 88.90584 $[Kr]4d5s^2$ 6.2173	40 $^3F_2$ **Zr** Zirconium 91.224 $[Kr]4d^2 5s^2$ 6.6339	41 $^6D_{1/2}$ **Nb** Niobium 92.90637 $[Kr]4d^4 5s$ 6.7589	42 $^7S_3$ **Mo** Molybdenum 95.95 $[Kr]4d^5 5s$ 7.0924	43 $^6S_{5/2}$ **Tc** Technetium (98) $[Kr]4d^5 5s^2$ 7.1194	44 $^5F_5$ **Ru** Ruthenium 101.07 $[Kr]4d^7 5s$ 7.3605	45 $^4F_{9/2}$ **Rh** Rhodium 102.90550 $[Kr]4d^8 5s$ 7.4589	46 $^1S_0$ **Pd** Palladium 106.42 $[Kr]4d^{10}$ 8.3369	47 $^2S_{1/2}$ **Ag** Silver 107.8682 $[Kr]4d^{10} 5s$ 7.5762	48 $^1S_0$ **Cd** Cadmium 112.414 $[Kr]4d^{10} 5s^2$ 8.9938	49 $^2P^o_{1/2}$ **In** Indium 114.818 $[Kr]4d^{10} 5s^2 5p$ 5.7864	50 $^3P_0$ **Sn** Tin 118.710 $[Kr]4d^{10} 5s^2 5p^2$ 7.3439	51 $^4S^o_{3/2}$ **Sb** Antimony 121.760 $[Kr]4d^{10} 5s^2 5p^3$ 8.6084	52 $^3P_2$ **Te** Tellurium 127.60 $[Kr]4d^{10} 5s^2 5p^4$ 9.0097	53 $^2P^o_{3/2}$ **I** Iodine 126.90447 $[Kr]4d^{10} 5s^2 5p^5$ 10.4513	54 $^1S_0$ **Xe** Xenon 131.293 $[Kr]4d^{10} 5s^2 5p^6$ 12.1298
6	55 $^2S_{1/2}$ **Cs** Cesium 132.9054520 [Xe]6s 3.8939	56 $^1S_0$ **Ba** Barium 137.327 $[Xe]6s^2$ 5.2117		72 $^3F_2$ **Hf** Hafnium 178.49 $[Xe]4f^{14} 5d^2 6s^2$ 6.8251	73 $^4F_{3/2}$ **Ta** Tantalum 180.94788 $[Xe]4f^{14} 5d^3 6s^2$ 7.5496	74 $^5D_0$ **W** Tungsten 183.84 $[Xe]4f^{14} 5d^4 6s^2$ 7.8640	75 $^6S_{5/2}$ **Re** Rhenium 186.207 $[Xe]4f^{14} 5d^5 6s^2$ 7.8335	76 $^5D_4$ **Os** Osmium 190.23 $[Xe]4f^{14} 5d^6 6s^2$ 8.4382	77 $^4F_{9/2}$ **Ir** Iridium 192.217 $[Xe]4f^{14} 5d^7 6s^2$ 8.9670	78 $^3D_3$ **Pt** Platinum 195.084 $[Xe]4f^{14} 5d^9 6s$ 8.9588	79 $^2S_{1/2}$ **Au** Gold 196.966569 $[Xe]4f^{14} 5d^{10} 6s$ 9.2256	80 $^1S_0$ **Hg** Mercury 200.592 $[Xe]4f^{14} 5d^{10} 6s^2$ 10.4375	81 $^2P^o_{1/2}$ **Tl** Thallium 204.38* [Hg]6p 6.1083	82 $^3P_0$ **Pb** Lead 207.2 $[Hg]6p^2$ 7.4167	83 $^4S^o_{3/2}$ **Bi** Bismuth 208.98040 $[Hg]6p^3$ 7.2855	84 $^3P_2$ **Po** Polonium (209) $[Hg]6p^4$ 8.414	85 $^2P^o_{3/2}$ **At** Astatine (210) $[Hg]6p^5$ 9.31751	86 $^1S_0$ **Rn** Radon (222) $[Hg]6p^6$ 10.7485
7	87 $^2S_{1/2}$ **Fr** Francium (223) [Rn]7s 4.0727	88 $^1S_0$ **Ra** Radium (226) $[Rn]7s^2$ 5.2784		104 $^3F_2$ **Rf** Rutherfordium (267) $[Rn]5f^{14} 6d^2 7s^2$ 6.01	105 $^4F_{3/2}$ **Db** Dubnium (268) $[Rn]5f^{14} 6d^3 7s^2$ 6.8	106 **Sg** Seaborgium (271) $[Rn]5f^{14} 6d^4 7s^2$ 7.8	107 **Bh** Bohrium (272) $[Rn]5f^{14} 6d^5 7s^2$ 7.7	108 **Hs** Hassium (270) $[Rn]5f^{14} 6d^6 7s^2$ 7.6	109 **Mt** Meitnerium (276)	110 **Ds** Darmstadtium (281)	111 **Rg** Roentgenium (280)	112 **Cn** Copernicium (285)	113 **Uut** Ununtrium (284)	114 **Fl** Flerovium (289)	115 **Uup** Ununpentium (288)	116 **Lv** Livermorium (293)	117 **Uus** Ununseptium (294)	118 **Uuo** Ununoctium (294)

Lanthanides	57 $^2D_{3/2}$ **La** Lanthanum 138.90547 [Xe]5d6s² 5.5769	58 $^1G^o_4$ **Ce** Cerium 140.116 $[Xe]4f5d6s^2$ 5.5386	59 $^4I^o_{9/2}$ **Pr** Praseodymium 140.907 $[Xe]4f^3 6s^2$ 5.473	60 $^5I_4$ **Nd** Neodymium 144.242 $[Xe]4f^4 6s^2$ 5.5250	61 $^6H^o_{5/2}$ **Pm** Promethium (145) $[Xe]4f^5 6s^2$ 5.582	62 $^7F_0$ **Sm** Samarium 150.36 $[Xe]4f^6 6s^2$ 5.6437	63 $^8S^o_{7/2}$ **Eu** Europium 151.964 $[Xe]4f^7 6s^2$ 5.6704	64 $^9D^o_2$ **Gd** Gadolinium 157.25 $[Xe]4f^7 5d6s^2$ 6.1498	65 $^6H^o_{15/2}$ **Tb** Terbium 158.92535 $[Xe]4f^9 6s^2$ 5.8638	66 $^5I_8$ **Dy** Dysprosium 162.500 $[Xe]4f^{10} 6s^2$ 5.9391	67 $^4I^o_{15/2}$ **Ho** Holmium 164.93033 $[Xe]4f^{11} 6s^2$ 6.0215	68 $^3H_6$ **Er** Erbium 167.259 $[Xe]4f^{12} 6s^2$ 6.1077	69 $^2F^o_{7/2}$ **Tm** Thulium 168.93422 $[Xe]4f^{13} 6s^2$ 6.1843	70 $^1S_0$ **Yb** Ytterbium 173.054 $[Xe]4f^{14} 6s^2$ 6.2542	71 $^2D_{3/2}$ **Lu** Lutetium 174.9668 $[Xe]4f^{14} 5d6s^2$ 5.4259
Actinides	89 $^2D_{3/2}$ **Ac** Actinium (227) [Rn]6d7s² 5.3802	90 $^3F_2$ **Th** Thorium 232.0377 $[Rn]6d^2 7s^2$ 6.3067	91 $^4K_{11/2}$ **Pa** Protactinium 231.03588 $[Rn]5f^2 6d7s^2$ 5.89	92 $^5L^o_6$ **U** Uranium 238.02891 $[Rn]5f^3 6d7s^2$ 6.1941	93 $^6L_{11/2}$ **Np** Neptunium (237) $[Rn]5f^4 6d7s^2$ 6.2655	94 $^7F_0$ **Pu** Plutonium (244) $[Rn]5f^6 7s^2$ 6.0258	95 $^8S^o_{7/2}$ **Am** Americium (243) $[Rn]5f^7 7s^2$ 5.9738	96 $^9D^o_2$ **Cm** Curium (247) $[Rn]5f^7 6d7s^2$ 5.9914	97 $^6H^o_{15/2}$ **Bk** Berkelium (247) $[Rn]5f^9 7s^2$ 6.1978	98 $^5I_8$ **Cf** Californium (251) $[Rn]5f^{10} 7s^2$ 6.2817	99 $^4I^o_{15/2}$ **Es** Einsteinium (252) $[Rn]5f^{11} 7s^2$ 6.3676	100 $^3H_6$ **Fm** Fermium (257) $[Rn]5f^{12} 7s^2$ 6.50	101 $^2F^o_{7/2}$ **Md** Mendelevium (258) $[Rn]5f^{13} 7s^2$ 6.58	102 $^1S_0$ **No** Nobelium (259) $[Rn]5f^{14} 7s^2$ 6.65	103 $^2P^o_{1/2}$ **Lr** Lawrencium (262) $[Rn]5f^{14} 7s^2 7p$ 4.90

Atomic Number
Ground-state Level
Symbol
Name
Standard Atomic Weight†
Ground-state Configuration
Ionization Energy (eV)

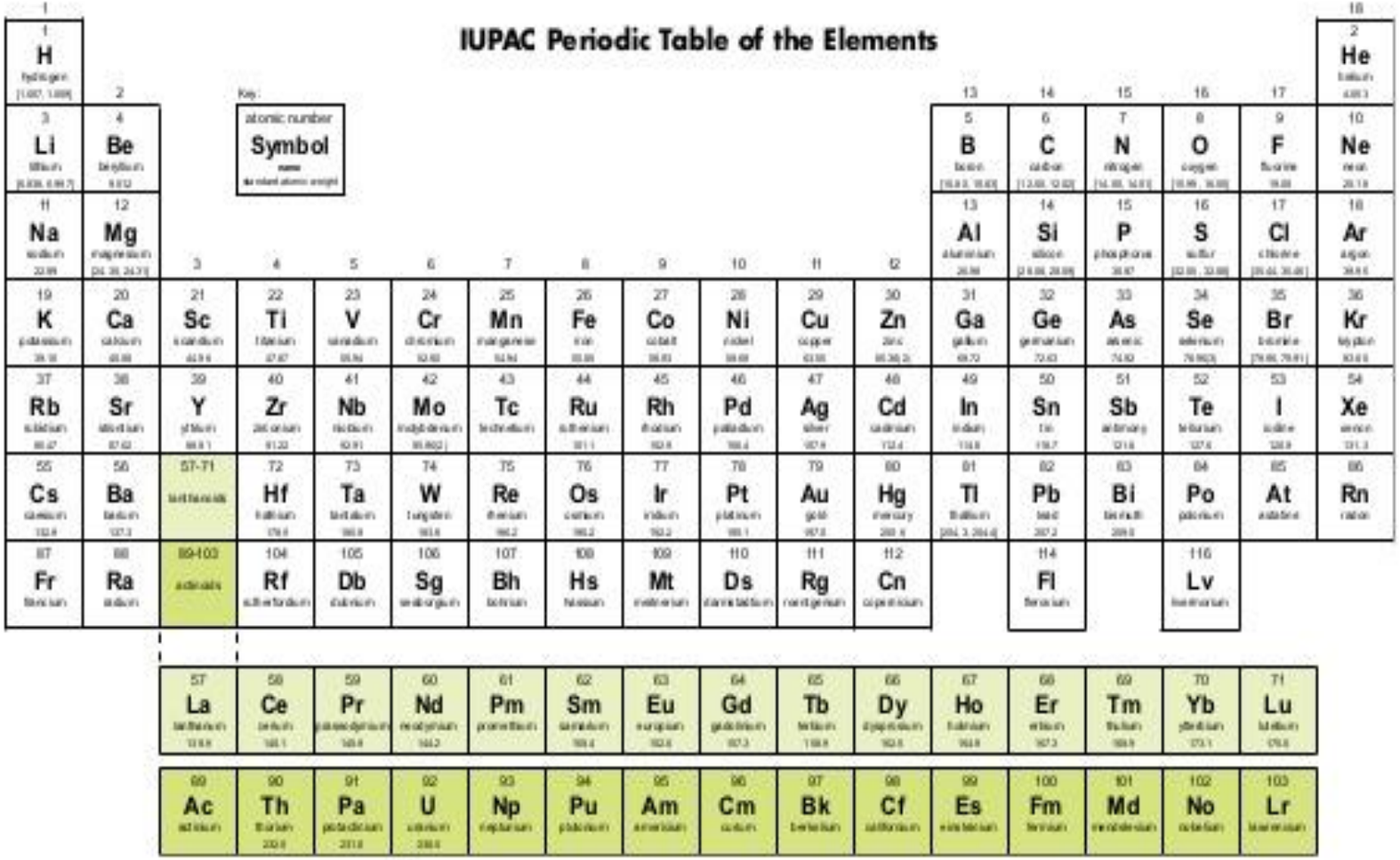
†Based upon ^{12}C. () indicates the mass number of the longest-lived isotope.

*IUPAC conventional atomic weights; standard atomic weights for these elements are expressed in intervals; see iupac.org for an explanation and values.

For a description of the data, visit physics.nist.gov/data

NIST SP 966 (September 2014)

IUPAC Periodic Table of the Elements



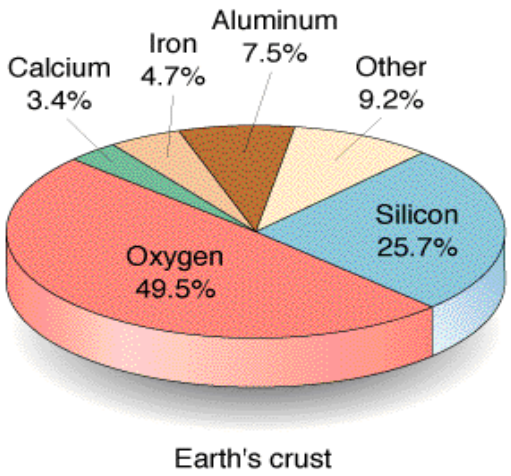
Notes

- IUPAC 2011 Standard atomic weights abridged to four significant digits (Table A) published in *Pure Appl. Chem.* 85, 1047-1078 (2013); http://dx.doi.org/10.1351/PAC-REP-13-03-02. The uncertainty in the last digit of the standard atomic weight value is listed in parentheses following the value. In the absence of parentheses, the uncertainty is one in that last digit. An interval in square brackets provides the lower and upper bounds of the standard atomic weight for that element. No values are listed for elements which lack isotopes with a characteristic isotopic abundance in natural terrestrial samples. See PAC for more details.
- "Aluminum" and "caesium" are commonly used alternative spellings for "aluminium" and "caesium."
- Claims for the discovery of all the remaining elements in the last row of the Table, namely elements with atomic numbers 113, 115, 117 and 118, and for which no assignments have yet been made, are being considered by a IUPAC and IUPAP Joint Working Party.

For updates to this table, see iupac.org/reports/periodic_table/. This version is dated 1 May 2013.

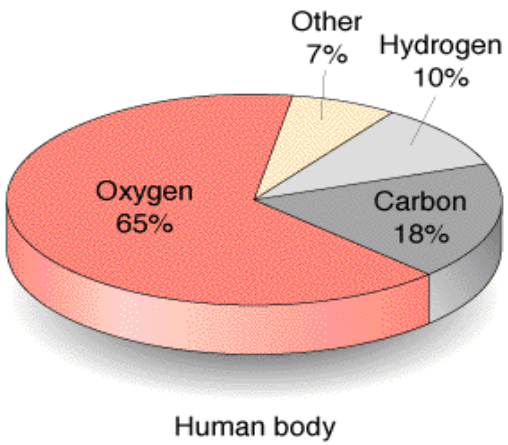
INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

Composições Atômicas Aproximadas da Crosta Terrestre e do Corpo Humano



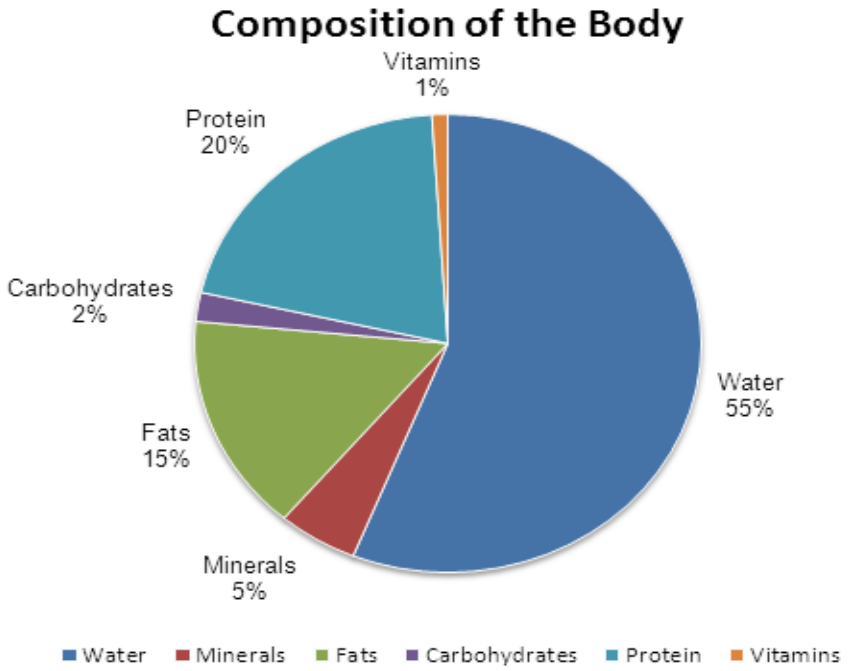
Earth's crust

(a)



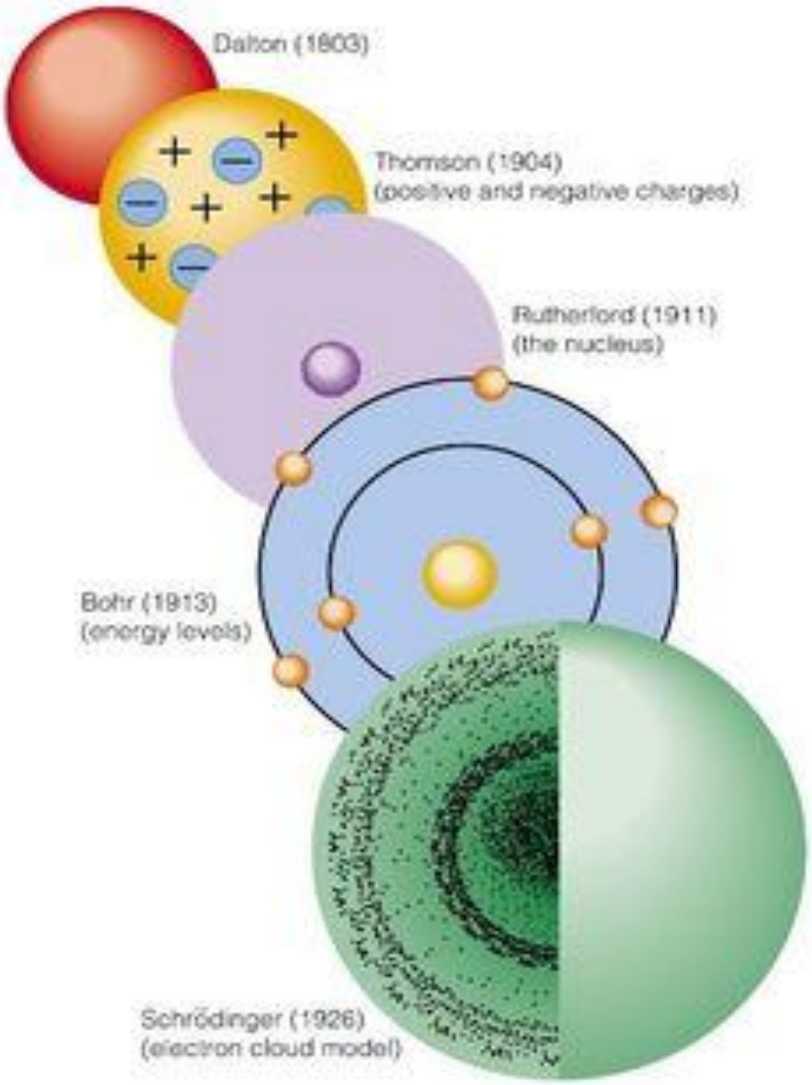
Human body

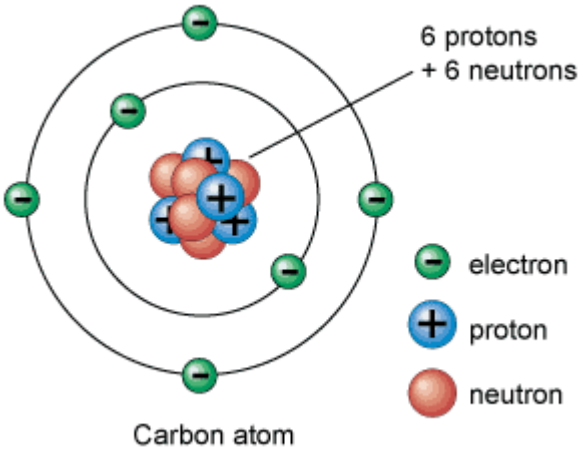
(b)



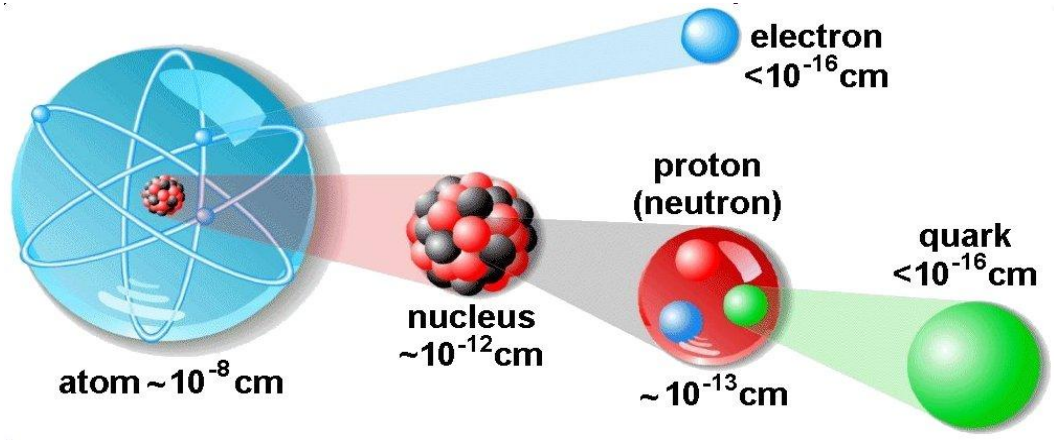
ESTRUTURA DA MATÉRIA
ÁTOMOS, MOLÉCULAS E ÍONS

Modelos Atômicos

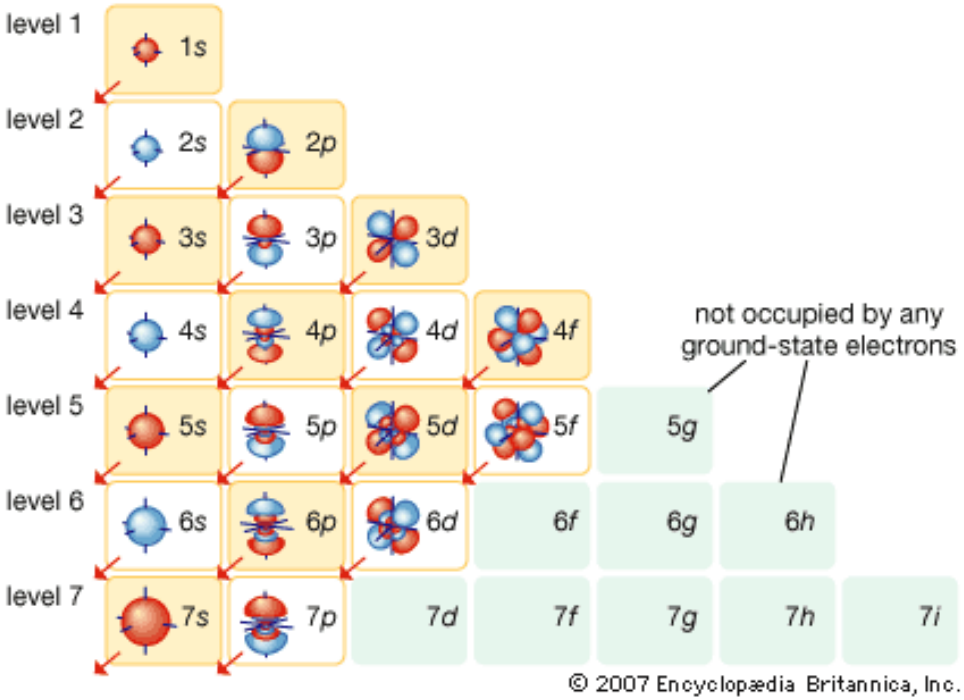


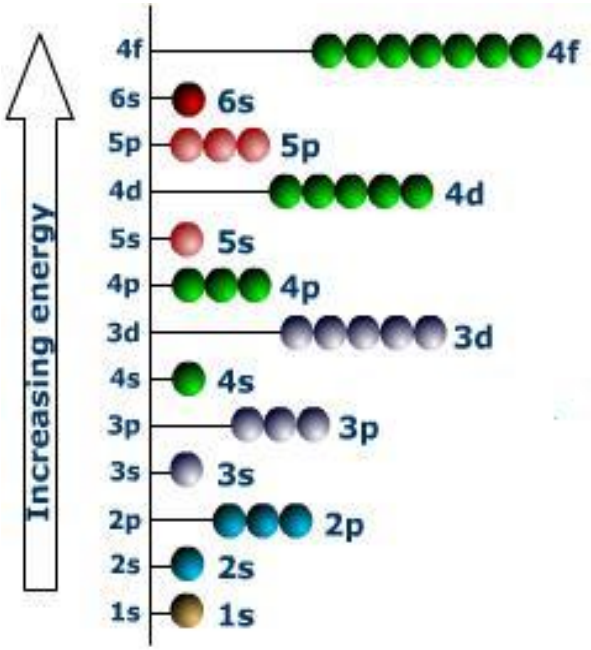


Dimensões



Distribuição Eletrônica em Átomos





Representação espacial dos orbitais atômicos s, p, d, e f degenerados

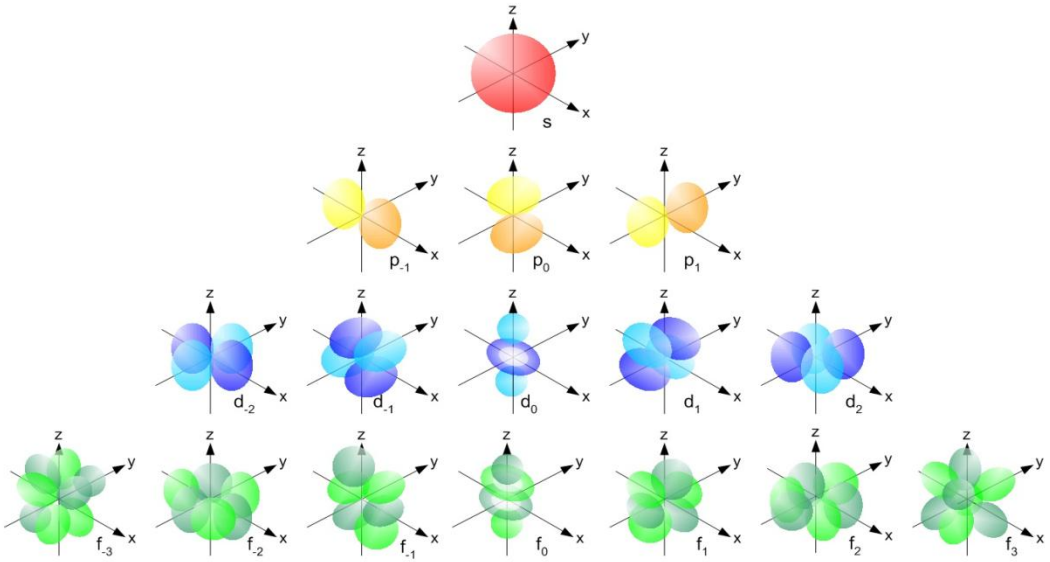
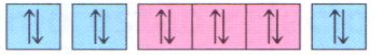
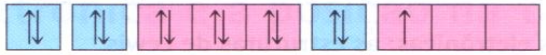
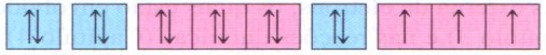
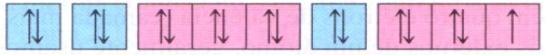
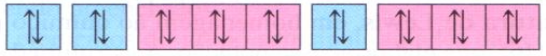
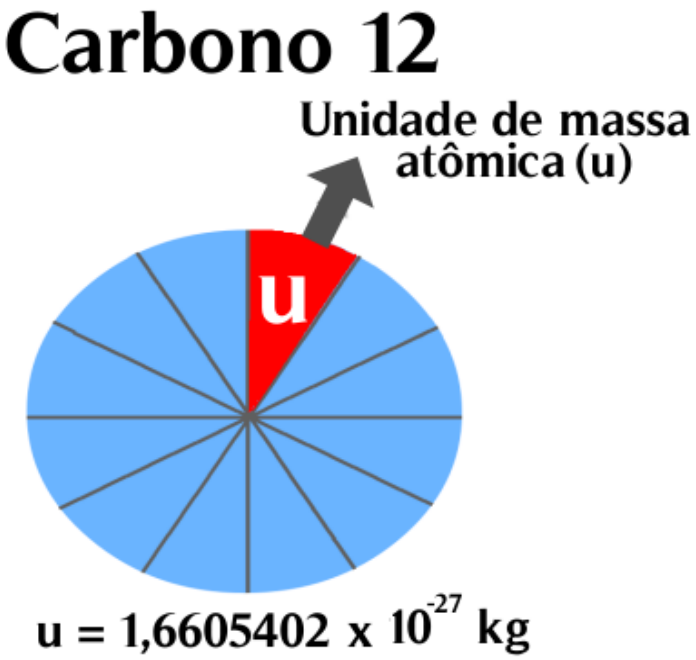


TABELA 2.7 Configurações eletrônicas do estado fundamental dos primeiros 18 elementos

	Diagrama de caixa de orbital 1s 2s 2px 2py 2pz 3s 3px 3py 3pz	Configuração eletrônica (condensada)	Notação dos gases nobres
H (1)		$1s^1$	
He (2)		$1s^2$	
Li (3)		$1s^2\ 2s^1$	[He] $2s^1$
Be (4)		$1s^2\ 2s^2$	[He] $2s^2$
B (5)		$1s^2\ 2s^2\ 2p^1$	[He] $2s^2\ 2p^1$
C (6)		$1s^2\ 2s^2\ 2p^2$	[He] $2s^2\ 2p^2$
N (7)		$1s^2\ 2s^2\ 2p^3$	[He] $2s^2\ 2p^3$
O (8)		$1s^2\ 2s^2\ 2p^4$	[He] $2s^2\ 2p^4$
F (9)		$1s^2\ 2s^2\ 2p^5$	[He] $2s^2\ 2p^5$
Ne (10)		$1s^2\ 2s^2\ 2p^6$	[He] $2s^2\ 2p^6$
Na (11)		$1s^2\ 2s^2\ 2p^6\ 3s^1$	[Ne] $3s^1$
Mg (12)		$1s^2\ 2s^2\ 2p^6\ 3s^2$	[Ne] $3s^2$
Al (13)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	[Ne] $3s^2\ 3p^1$
Si (14)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$	[Ne] $3s^2\ 3p^2$
P (15)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$	[Ne] $3s^2\ 3p^3$
S (16)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$	[Ne] $3s^2\ 3p^4$
Cl (17)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	[Ne] $3s^2\ 3p^5$
Ar (18)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	[Ne] $3s^2\ 3p^6$

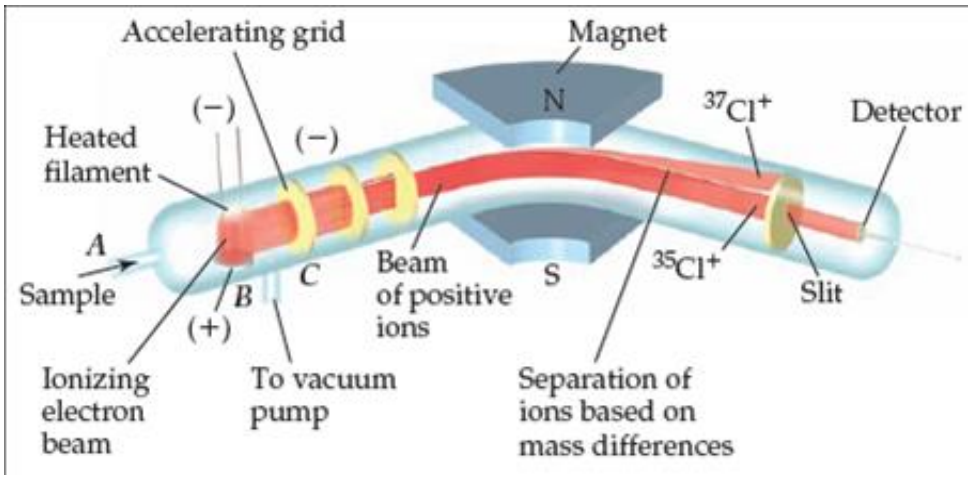
Neônio (Ne) O neônio, número atômico 10, tem dez elétrons em seus átomos neutros, que preenchem completamente todos os orbitais da primeira e segunda camadas. O estado fundamental do átomo de neônio não tem elétrons não emparelhados.

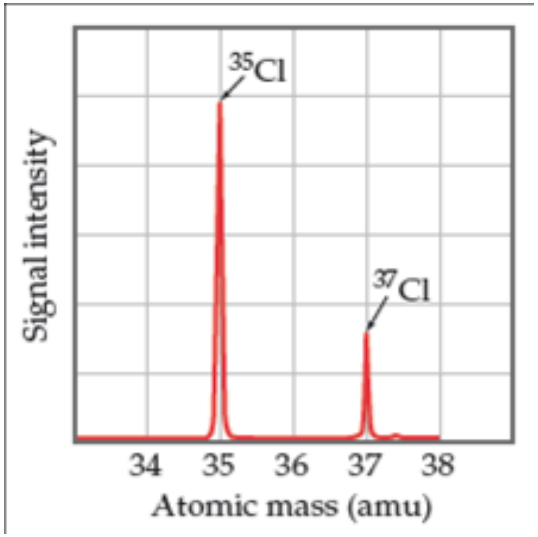
UNIDADE DE MASSA ATÔMICA (u ou uma)



1 grama (g) = $6{,}02214 \times 10^{23}$ u

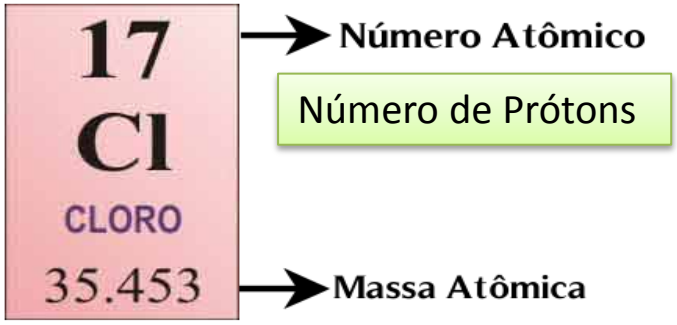
Determinação da abundância dos isótopos por espectrometria de massa
Separação pela razão massa/carga em um campo magnético





75,78 %

24,22 %



A massa atômica do cloro é aproximadamente 35,5u.

Cálculo da massa atômica ponderada/média devido a presença de isótopos

<M> = 0.7578x34,969 + 0.2422x36,966 = **35,453 u**

Assim 1 mol de átomos de Cl tem massa média de 35,453 g ou a massa molar do Cl é **35,453 g/mol**

CÁLCULO DE MASSA MOLECULAR E MASSA MOLAR DE COMPOSTOS QUÍMICOS

Definição: A massa molecular de um composto é a soma das massas atômicas (ponderadas) dos átomos que constituem a molécula.

Obs: Valores tomados de uma boa tabela periódica

A massa molar é a massa de 1 mol de moléculas do composto.

Exemplo: massa molecular HCl

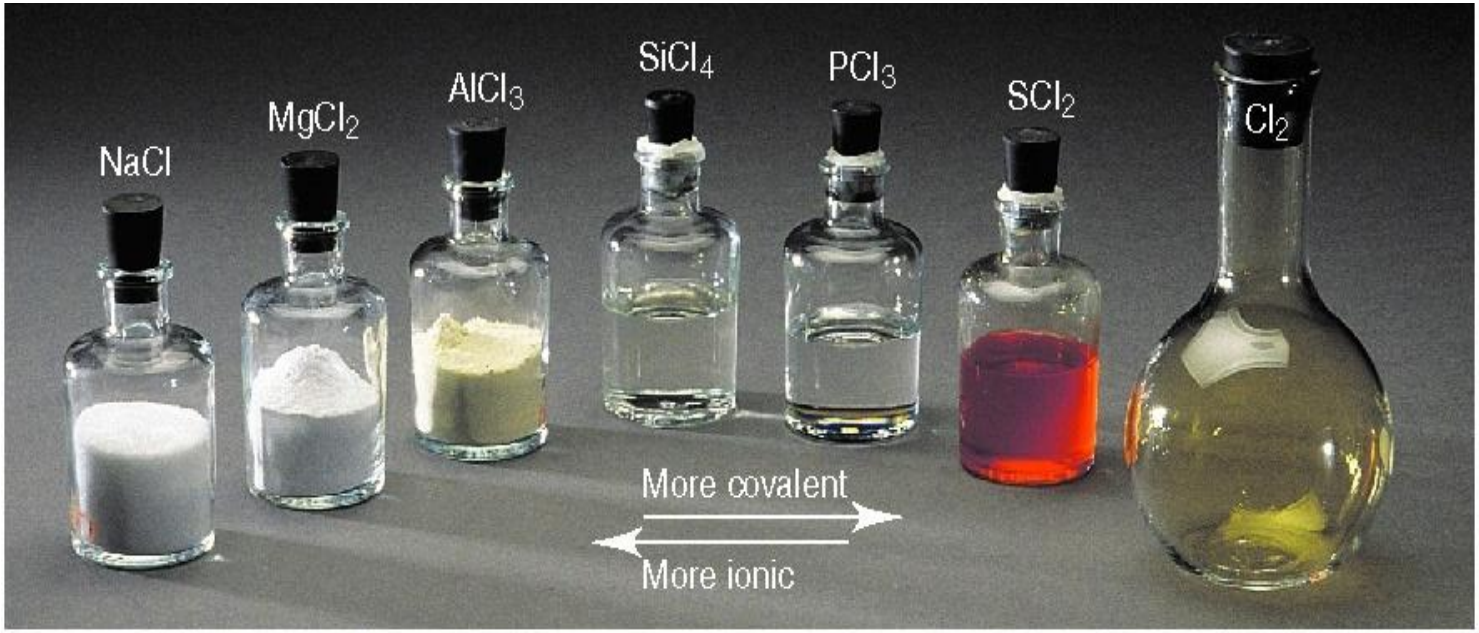
1,008 u + 35,453 u = 36,461 u

Massa molar HCl = 36,461 g/mol

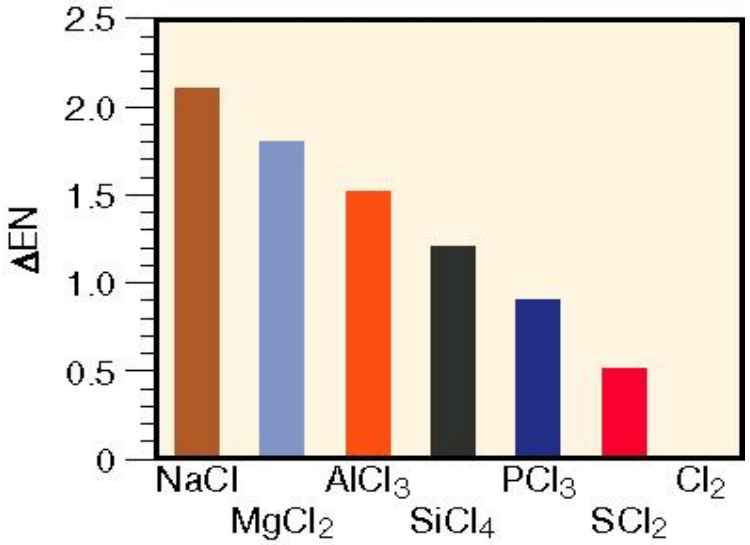
$u = 1,66054 \times 10^{-24}$ g

1 grama (g) = $6,02214 \times 10^{23}$ u

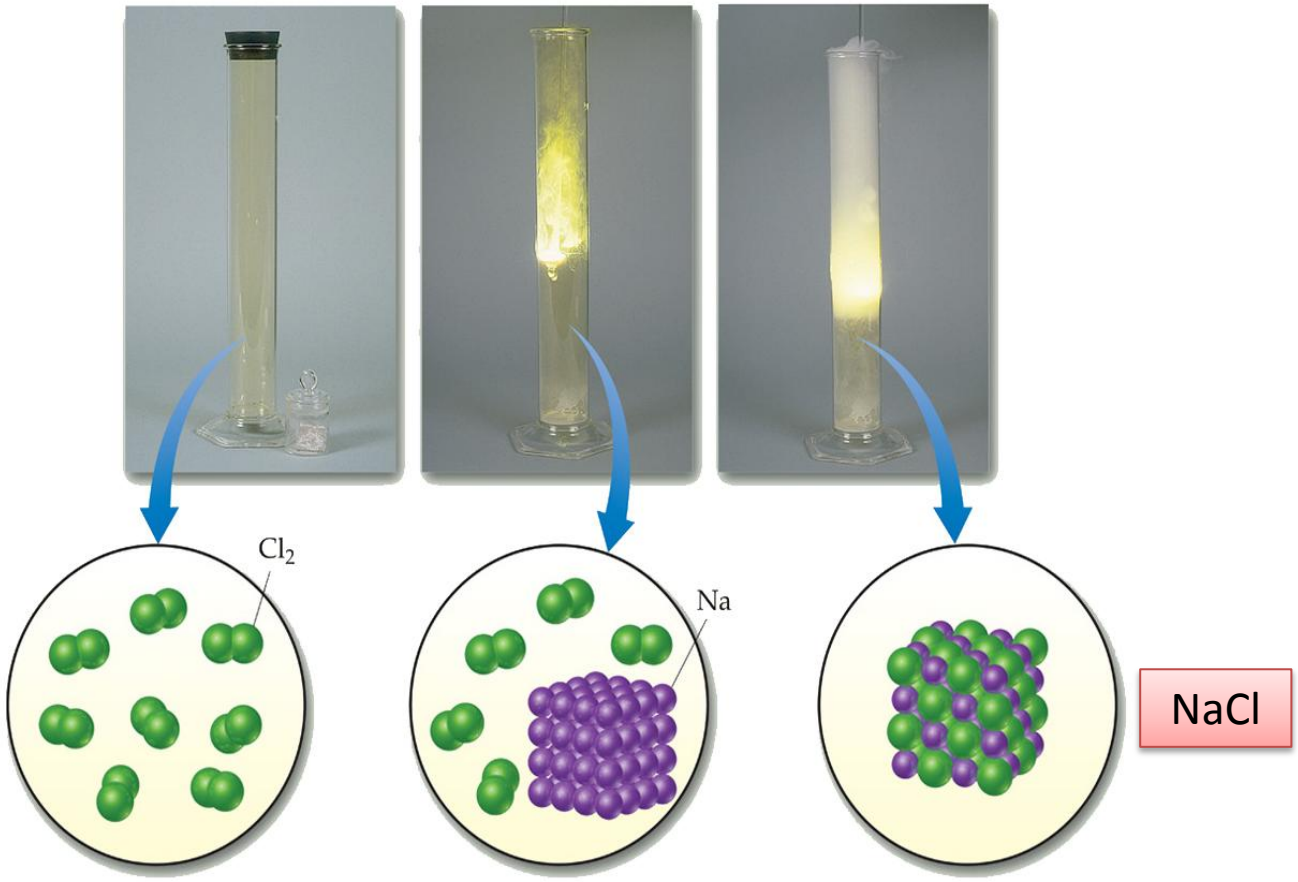
COMPOSTOS IÔNICOS E COVALENTES



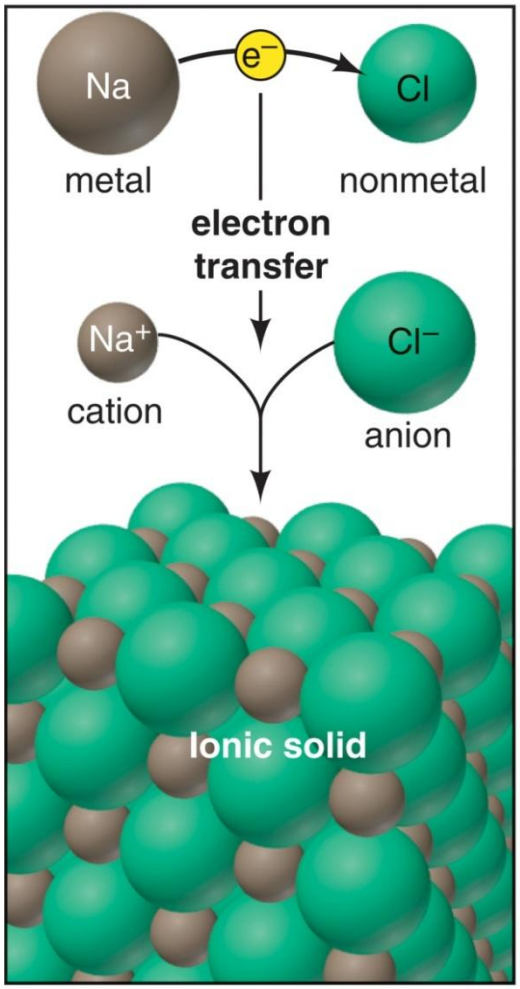
VARIAÇÃO DE ELETRONEGATIVIDADE



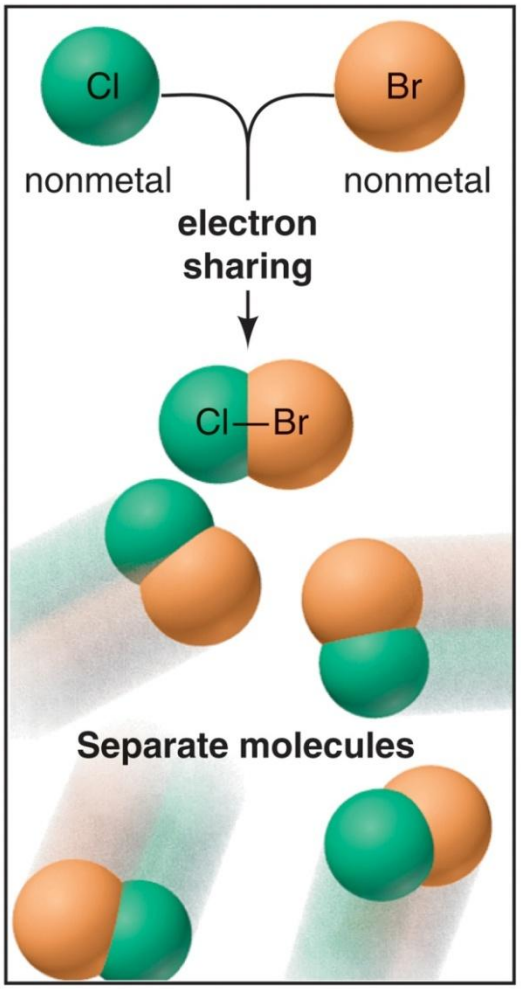
Reação de um metal alcalino com um halogênio gerando um sal (sólido iônico)



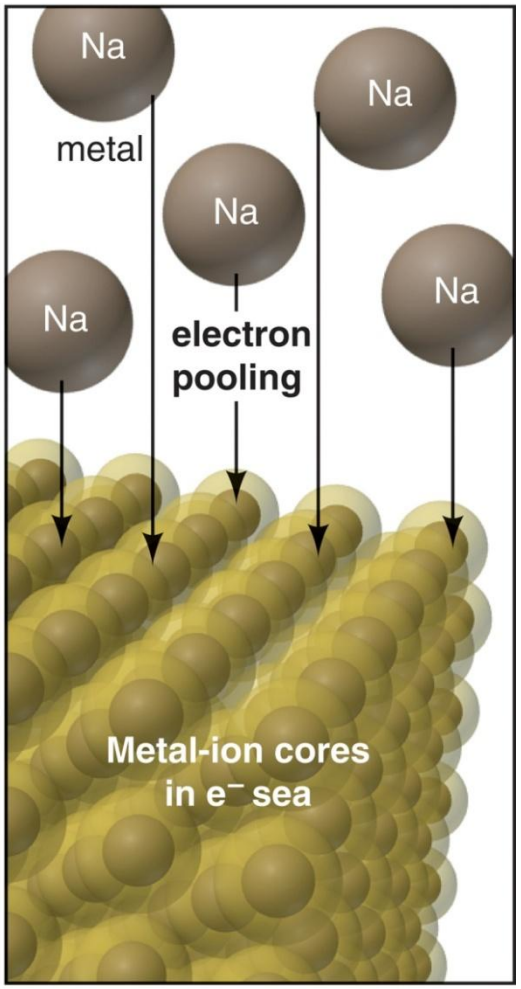
TIPOS DE LIGAÇÃO QUÍMICA



A Ionic bonding

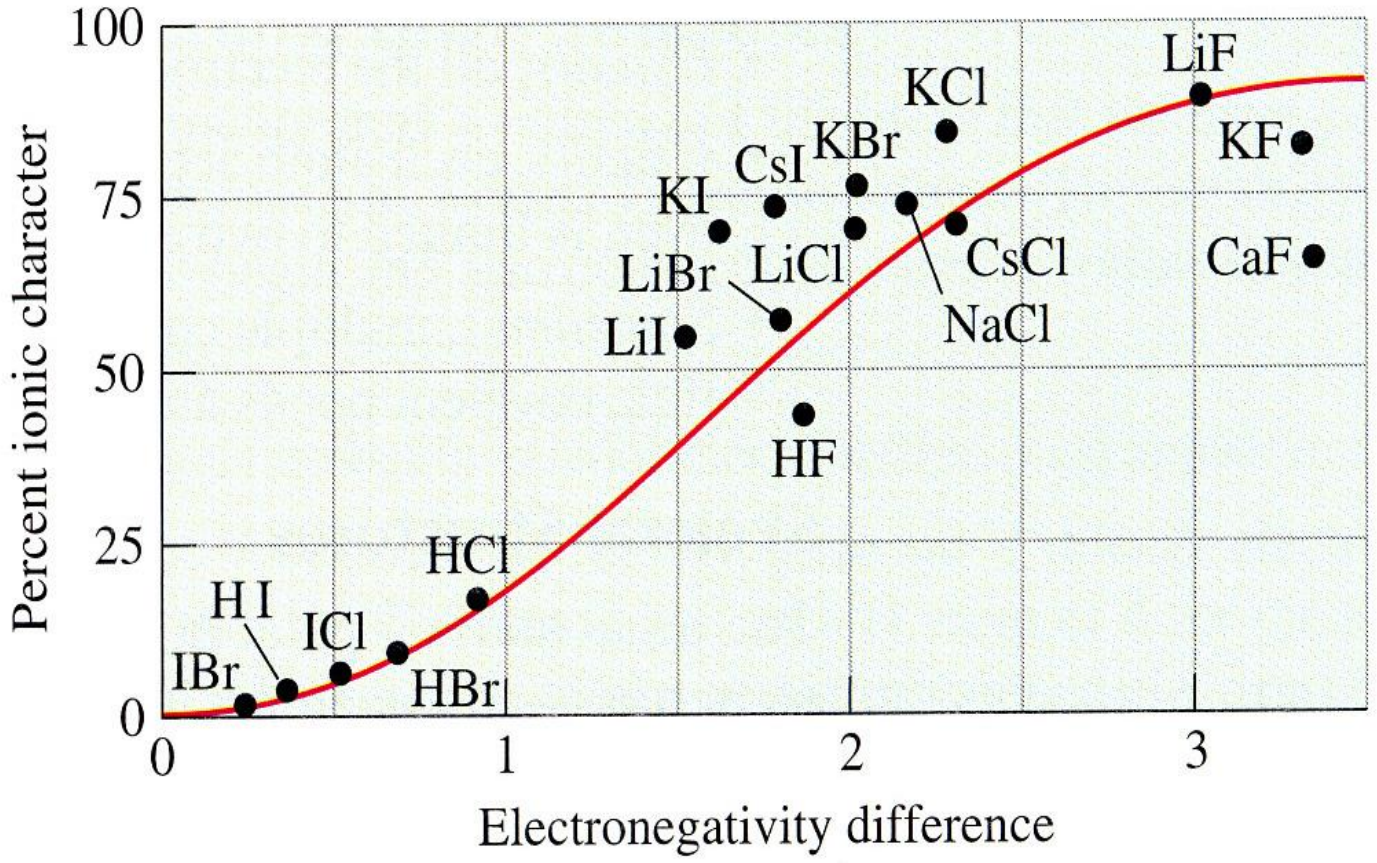


B Covalent bonding

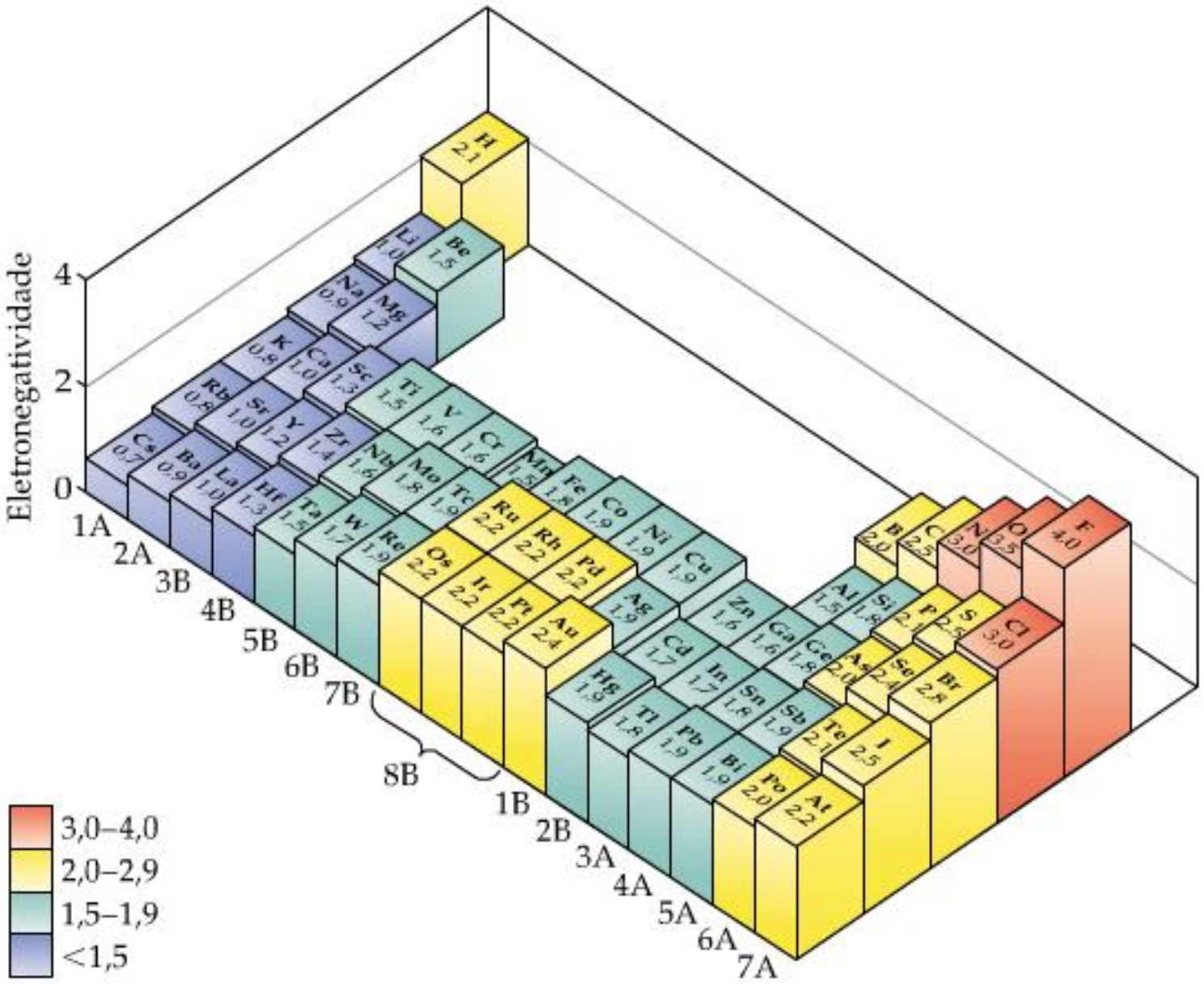


C Metallic bonding

Caráter Iônico ou Covalente de Compostos Binários em Função da diferença de Eletronegatividade

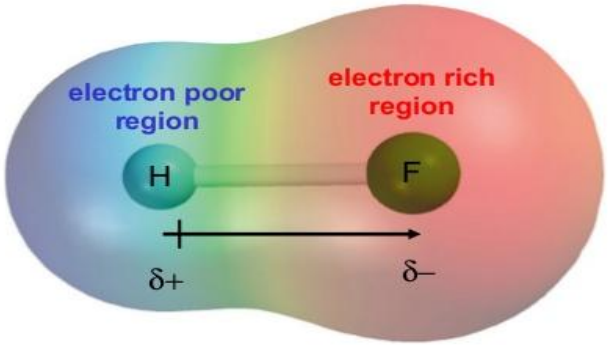


ESCALA DE ELETRONEGATIVIDADE DOS ELEMENTOS



POLARIDADE DE MOLÉCULAS DIATÔMICAS

Dipole Moments and Polar Molecules



$\mu = Q \times r$

Q is the charge

r is the distance between charges

1 D = 3.36×10^{-30} C m

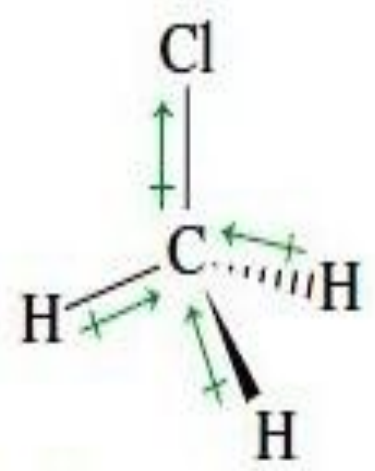
31

TABLE 8.3 Bond Lengths, Electronegativity Differences, and Dipole Moments of the Hydrogen Halides

Compound	Bond Length (Å)	Electronegativity Difference	Dipole Moment (D)
HF	0.92	1.9	1.82
HCl	1.27	0.9	1.08
HBr	1.41	0.7	0.82
HI	1.61	0.4	0.44

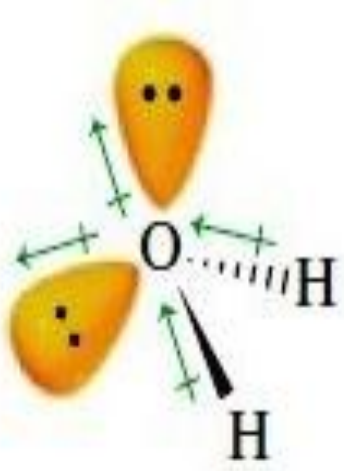
POLARIDADE DE MOLÉCULAS POLIATÔMICAS

Depende: Geometria, diferença de eletronegatividade, presença de orbitais com pares de elétrons não ligantes



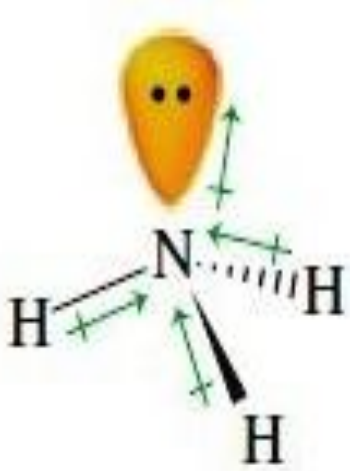
chloromethane

$\mu = 1.87$ D



water

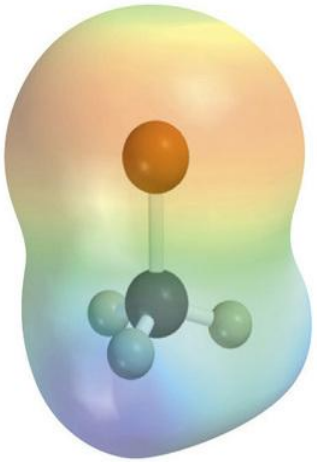
$\mu = 1.85$ D

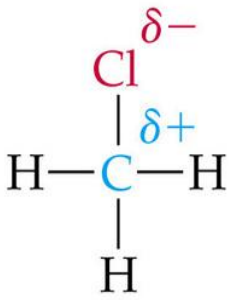


ammonia

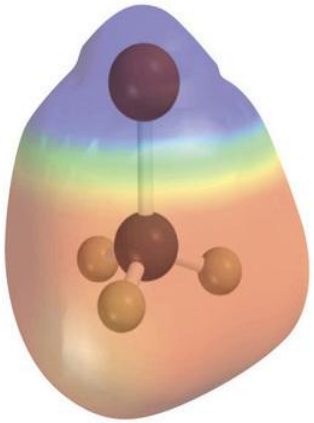
$\mu = 1.47$ D

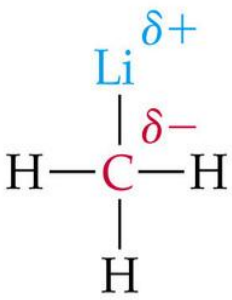
Exemplo de inversão de polaridade





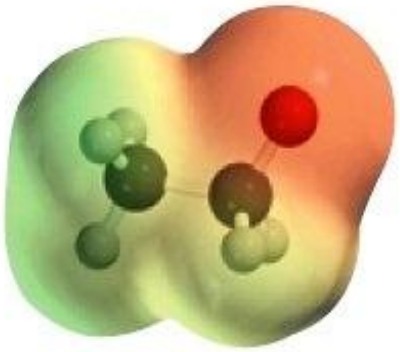
Chloromethane, CH_3Cl
(electron-poor carbon)



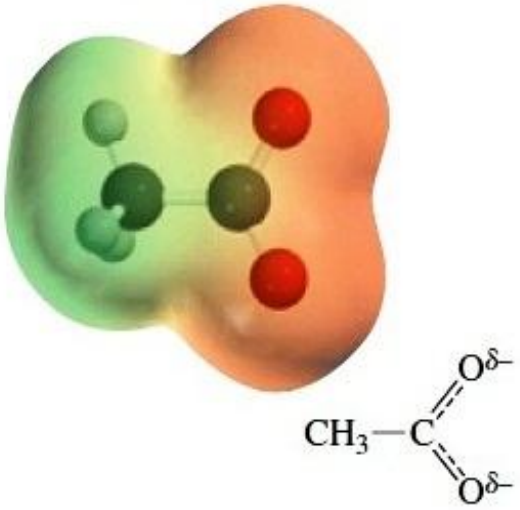


Methyllithium, CH_3Li
(electron-rich carbon)

Efeito de Localização de carga e Deslocalização (via ressonância) na polaridade de compostos químicos



$CH_3CH_2O^-$

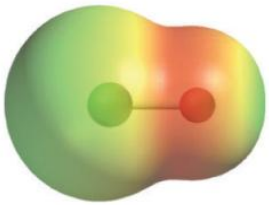


$CH_3-C(=O^{\delta-})-O^{\delta-}$

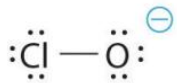
Íon Etóxido
Carga (-)
localizada

Íon Acetato
Carga (-)
delocalizada

Efeito de Ressonância na polaridade

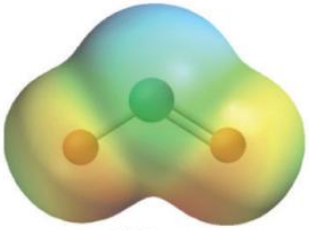


ClO^-

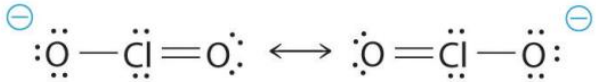


Hipoclorito

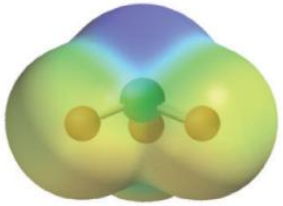
electron rich — electron poor



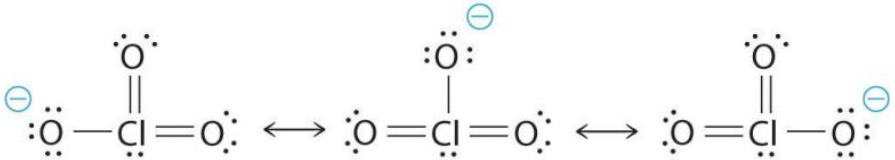
ClO_2^-



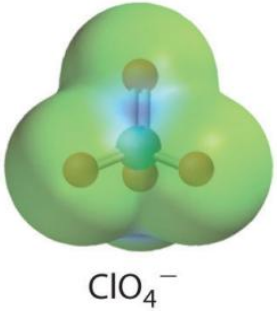
Clorito



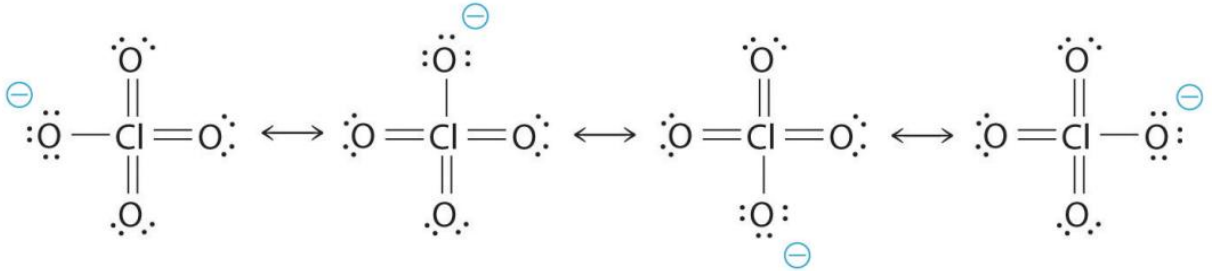
ClO_3^-



Clorato



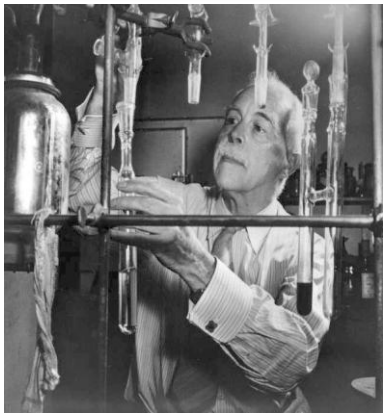
ClO_4^-



Perclorato

TEORIAS DE LIGAÇÃO QUÍMICA
PERSPECTIVA HISTÓRICA

Gilbert N. Lewis

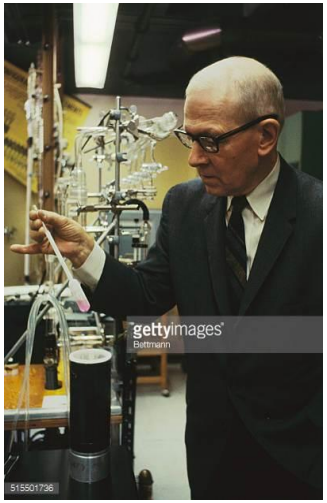


1) TEORIA DE LEWIS (1902 – 1913) REGRA DO OCTETO

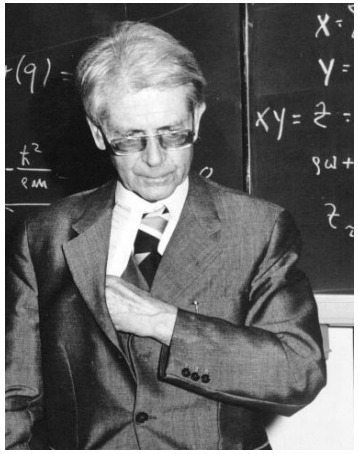
2) TEORIA DA LIGAÇÃO DE VALÊNCIA (1927 – 1932)
HIBRIDIZAÇÃO DE ORBITAIS ATÔMICOS

Linus Pauling

3) TEORIA DO ORBITAL MOLECULAR (1933 – ATUAL)
LIGAÇÃO QUÍMICA DESLOCALIZADA



Robert Mulliken



Friedrich Hund

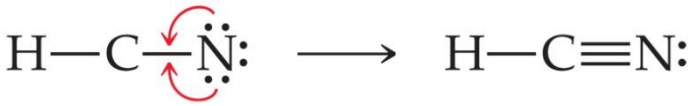
TABLE 8.1 Lewis Symbols

Element	Electron Configuration	Lewis Symbol
Li	$[He]2s^1$	Li·
Be	$[He]2s^2$	·Be·
B	$[He]2s^2 2p^1$	·Ḃ·
C	$[He]2s^2 2p^2$	·Ċ·
N	$[He]2s^2 2p^3$	·Ṅ:
O	$[He]2s^2 2p^4$	:Ȯ:
F	$[He]2s^2 2p^5$	·F̈:
Ne	$[He]2s^2 2p^6$	:N̈e:
Na	$[Ne]3s^1$	Na·
Mg	$[Ne]3s^2$	·Mg·
Al	$[Ne]3s^2 3p^1$	·Ȧl·
Si	$[Ne]3s^2 3p^2$	·Ṡi·
P	$[Ne]3s^2 3p^3$	·Ṗ:
S	$[Ne]3s^2 3p^4$	:Ṡ:
Cl	$[Ne]3s^2 3p^5$	·C̈l:
Ar	$[Ne]3s^2 3p^6$	:Ar:

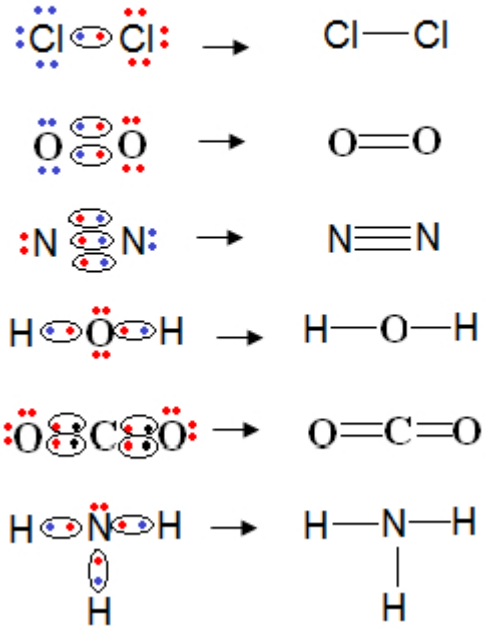
Teoria de Lewis
Regra do Octeto

Passo 1: Interligo os elementos

Passo 2:Complemento o octeto do átomo central



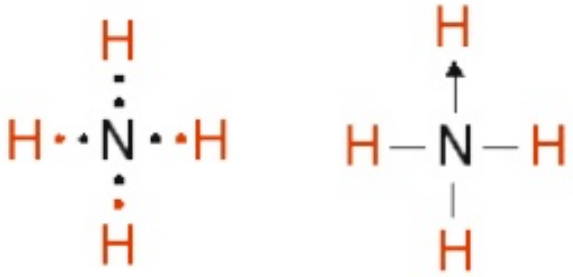
Fórmulas eletrônicas: Fórmulas estruturais planas:



Sem muitos detalhes de geometria molecular

Exceções a Regra do Octeto

o caso da ligação covalente dativa ou coordenada:



exceções à regra do octeto:

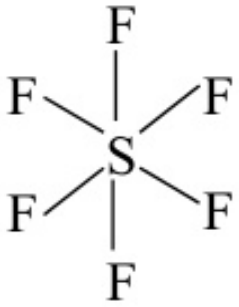
$$F-Be-F$$

menos de 8 elétrons

$$N=O$$

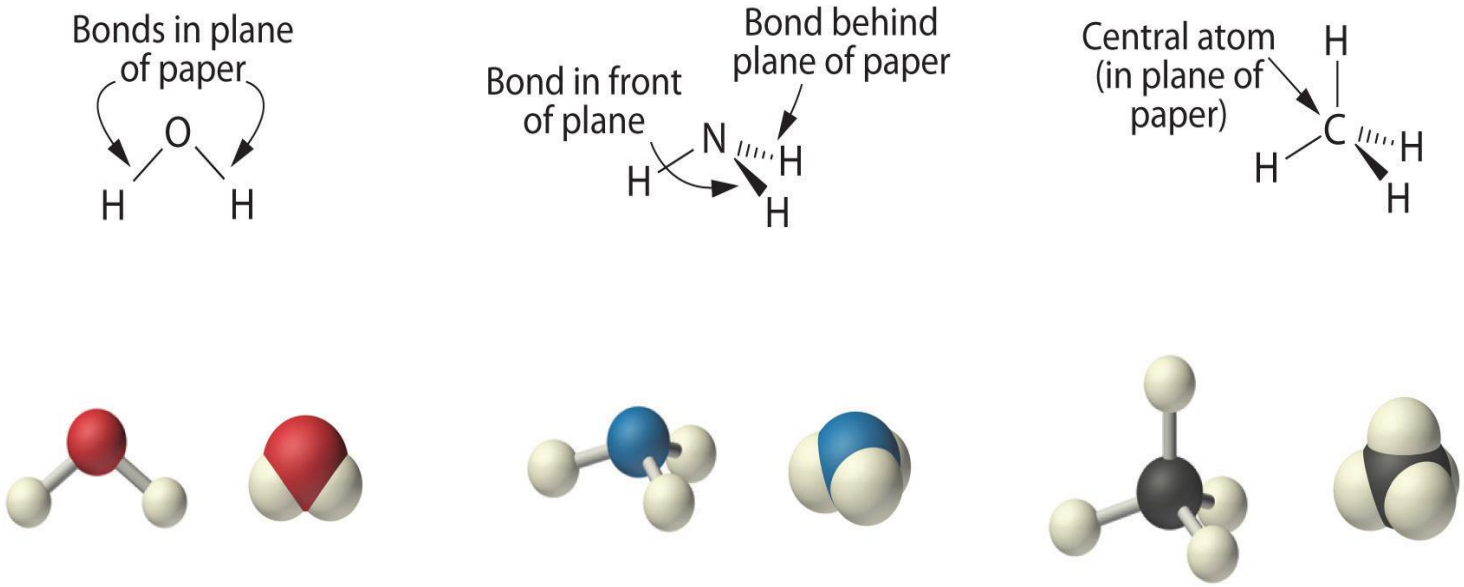
número ímpar de elétrons

(radical livre)



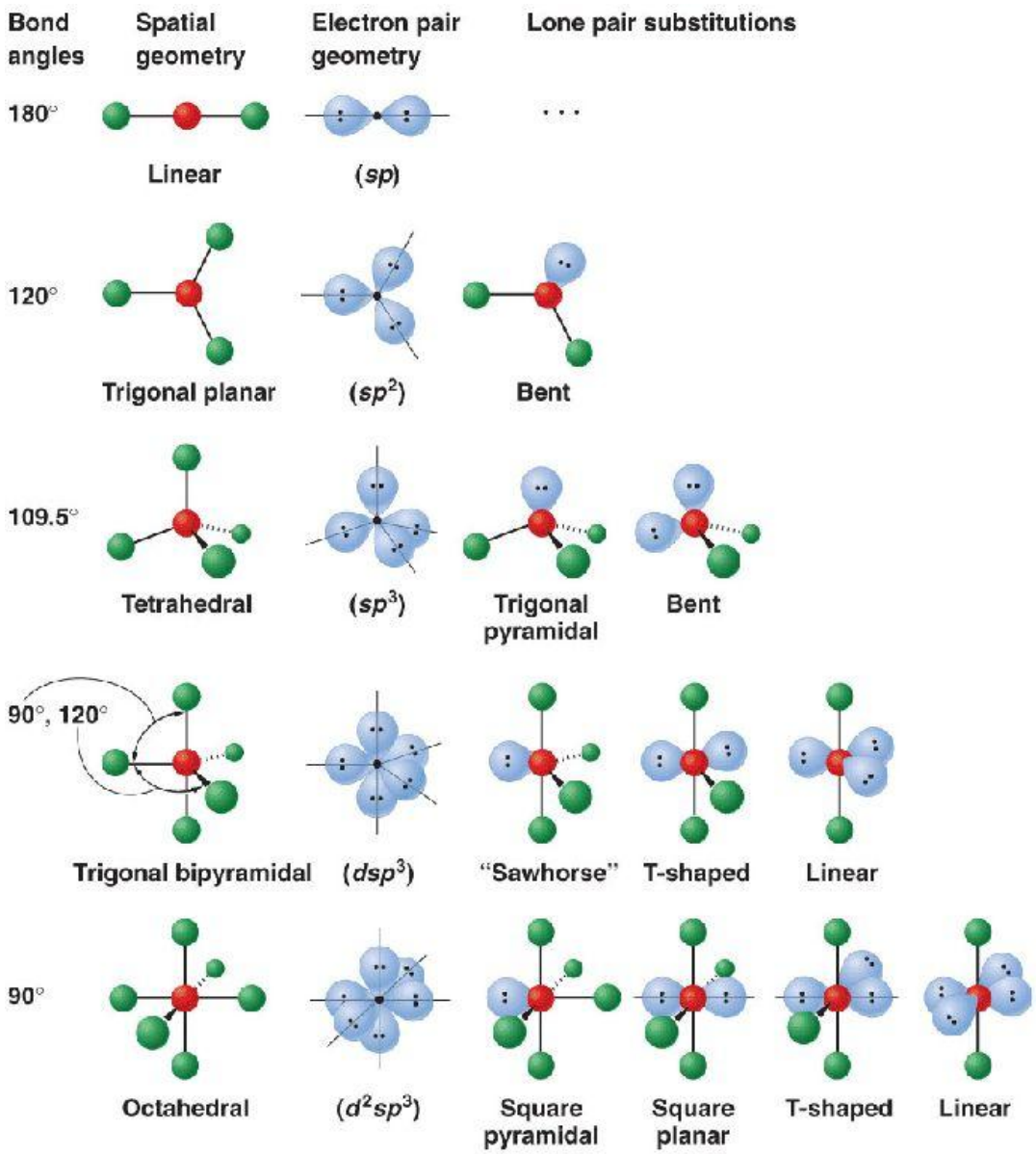
mais de 8 elétrons

2) TEORIA DA LIGAÇÃO DE VALÊNCIA (1927 – 1932)
HIBRIDIZAÇÃO DE ORBITAIS ATÔMICOS
GEOMETRIA DE MOLÉCULAS POLIATÔMICAS



(a) Water, H_2O (b) Ammonia, NH_3 (c) Methane, CH_4

Teoria de Ligação de Valência – Geometrias moleculares em função de ligações e pares de elétrons não ligantes



Energia média de Ligação (kJ/mol) e distância de ligação (pm)

Bond	Energy	Length	Bond	Energy	Length	Bond	Energy	Length	Bond	Energy	Length
Single Bonds											
H—H	432	74	N—H	391	101	Si—H	323	148	S—H	347	134
H—F	565	92	N—N	160	146	Si—Si	226	234	S—S	266	204
H—Cl	427	127	N—P	209	177	Si—O	368	161	S—F	327	158
H—Br	363	141	N—O	201	144	Si—S	226	210	S—Cl	271	201
H—I	295	161	N—F	272	139	Si—F	565	156	S—Br	218	225
			N—Cl	200	191	Si—Cl	381	204	S—I	~170	234
C—H	413	109	N—Br	243	214	Si—Br	310	216			
C—C	347	154	N—I	159	222	Si—I	234	240	F—F	159	143
C—Si	301	186							F—Cl	193	166
C—N	305	147	O—H	467	96	P—H	320	142	F—Br	212	178
C—O	358	143	O—P	351	160	P—Si	213	227	F—I	263	187
C—P	264	187	O—O	204	148	P—P	200	221	Cl—Cl	243	199
C—S	259	181	O—S	265	151	P—F	490	156	Cl—Br	215	214
C—F	453	133	O—F	190	142	P—Cl	331	204	Cl—I	208	243
C—Cl	339	177	O—Cl	203	164	P—Br	272	222	Br—Br	193	228
C—Br	276	194	O—Br	234	172	P—I	184	246	Br—I	175	248
C—I	216	213	O—I	234	194				I—I	151	266
Multiple Bonds											
C=C	614	134	N=N	418	122	C≡C	839	121	N≡N	945	110
C=N	615	127	N=O	607	120	C≡N	891	115	N≡O	631	106
C=O	745 (799 in CO_2)	123	O_2	498	121	C≡O	1070	113			