Átomos hidrogenoides

y la Tabla Periódica

Clase Previa

- ✓ Pozo infinito 3D $\rightarrow$ (n_x n_y n_z) + s
- ✓ Principio Exclusión de Pauli:

Los fermiones (electrones) se distribuyen en niveles de energía de forma tal de que no pueden existir dos electrones con igual conjunto de números cuánticos.

- ✓ Existen estados degenerados: misma energía pero diferente conjunto de números cuánticos.

Átomos de un electrón

- ✓ Ecuación Schrödinger 3D para: $V(r) = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}$

$$\Psi(r,\theta,\phi,t) = R(r)\Theta(\theta)\Phi(\phi)\exp(i\tfrac{E}{\hbar}t)$$

$$\frac{1}{\Phi}\frac{d^2\Phi}{d\phi^2} = -m_l^2$$

$$\frac{1}{sen\theta}\frac{d}{d\theta}\left(sen\theta\frac{d\Theta}{d\theta}\right) - \frac{m_l^2}{sen^2\theta}\Theta = l(l+1)\Theta$$

$$\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) - l(l+1)R + \frac{2m}{\hbar^2}r^2[E - V(r)]R = 0$$

Átomos de un electrón

- ✓ Ecuación Schrödinger 3D para: $V(r) = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}$

$$\Psi(r,\theta,\phi,t) = R(r)\Theta(\theta)\Phi(\phi)\exp(i\tfrac{E}{\hbar}t)$$

$$\frac{1}{\Phi}\frac{d^2\Phi}{d\phi^2} = -m_l^2 \quad \Rightarrow \quad |m_l| = 0,1,2,3\ldots.$$

$$\frac{1}{sen\theta}\frac{d}{d\theta}\left(sen\theta\frac{d\Theta}{d\theta}\right) - \frac{m_l^2}{sen^2\theta}\Theta = l(l+1)\Theta \quad \Rightarrow \quad 0 \le l \le |m_l|$$

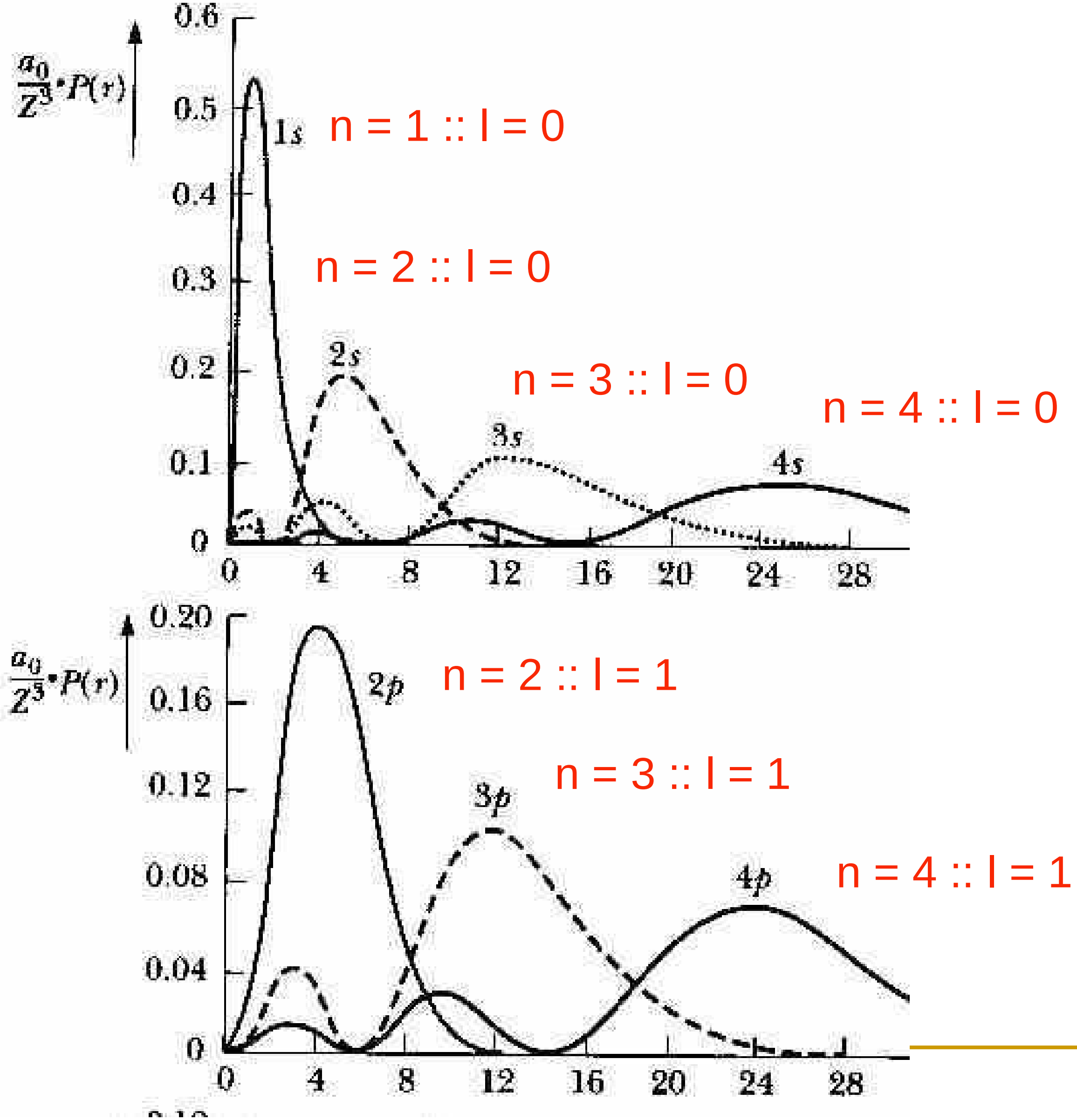
$$\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) - l(l+1)R + \frac{2m}{\hbar^2}r^2[E - V(r)]R = 0 \quad \Rightarrow \quad 1 \le n \le l+1$$

$$E_n = -\frac{Z^2}{n^2}13.6eV \qquad a_0 = \frac{4\pi\varepsilon_0\hbar^2}{me^2} = 0.53A$$

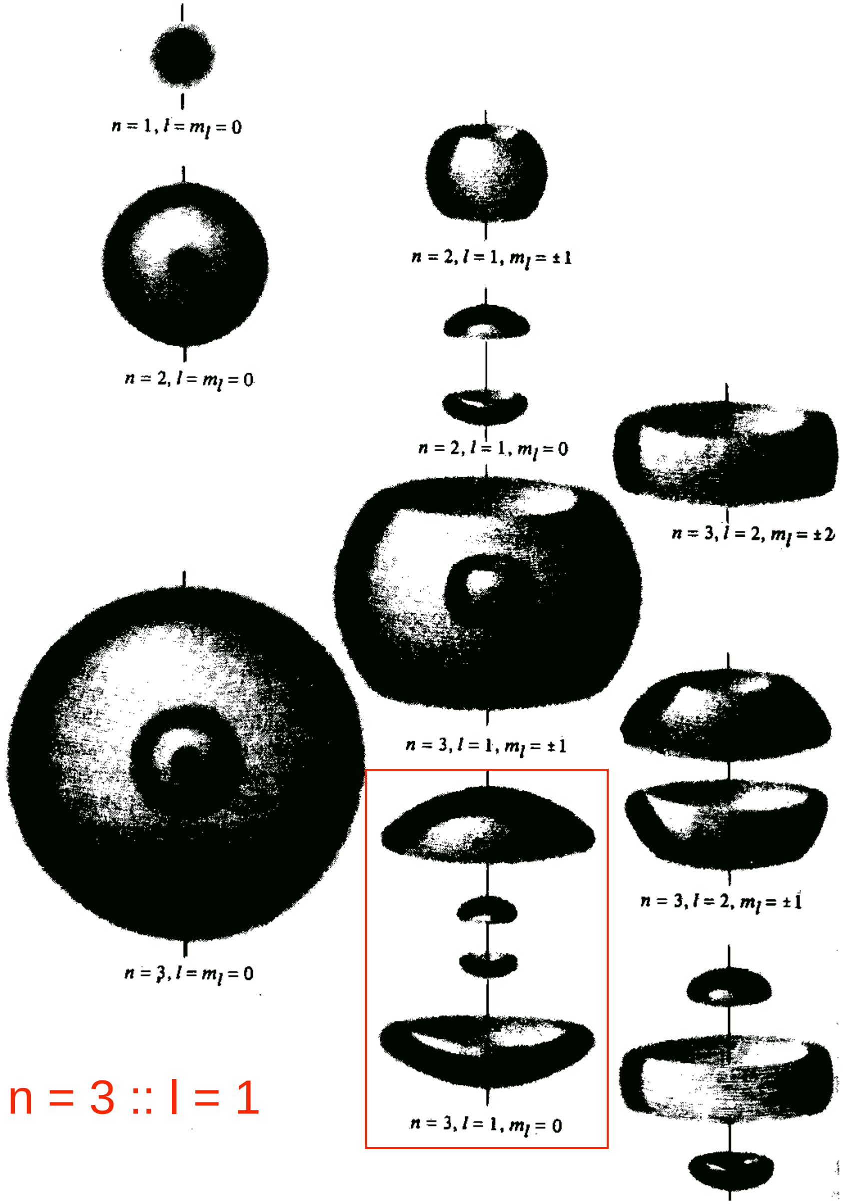
TABLA 4.1.
Funciones de onda del átomo de hidrógeno

$n=1$	$l=0$	$m=0$	$\psi_{100}=N_{100}e^{-\frac{1}{2}\rho}$	1s
$n=2$	$l=0$	$m=0$	$\psi_{200}=N_{200}(2-\rho)e^{-\frac{1}{2}\rho}$	2s
	$l=1$	$m=0$	$\psi_{210}=N_{210}\rho e^{-\frac{1}{2}\rho}\cos\theta$	$2p^3$
(4 estados)		$m=\pm1$	$\psi_{21\pm1}=N_{211}\rho e^{-\frac{1}{2}\rho}\,\mathrm{sen}\,\theta\, e^{\pm i\phi}$	
$n=3$	$l=0$	$m=0$	$\psi_{300}=N_{300}(6-6\rho+\rho^2)e^{-\frac{1}{2}\rho}$	3s
	$l=1$	$m=0$	$\psi_{310}=N_{310}\rho(4-\rho)e^{-\frac{1}{2}\rho}\cos\theta$	$3p^3$
		$m=\pm1$	$\psi_{31\pm1}=N_{311}\rho(4-\rho)e^{-\frac{1}{2}\rho}\,\mathrm{sen}\,\theta\, e^{\pm i\phi}$	
	$l=2$	$m=0$	$\psi_{320}=N_{320}\rho^2e^{-\frac{1}{2}\rho}(3\cos^2\theta-1)$	$3d^5$
		$m=\pm1$	$\psi_{32\pm1}=N_{321}\rho^2e^{-\frac{1}{2}\rho}\,\mathrm{sen}\,\theta\cos\theta\, e^{\pm i\phi}$	
(9 estados)		$m=\pm2$	$\psi_{32\pm2}=N_{322}\rho^2e^{-\frac{1}{2}\rho}\,\mathrm{sen}^2\theta\, e^{\pm 2i\phi}$	
$n=4$	$l=0$	$m=0$	$\psi_{400}=N_{400}(24-36\rho+12\rho^2-\rho^3)e^{-\frac{1}{2}\rho}$	4s
	$l=1$	$m=0$	$\psi_{410}=N_{410}\rho e^{-\frac{1}{2}\rho}(20-10\rho+\rho^2)\cos\theta$	$4p^3$
		$m=\pm1$	$\psi_{41\pm1}=N_{411}\rho e^{-\frac{1}{2}\rho}(20-10\rho+\rho^2)\,\mathrm{sen}\,\theta\, e^{\pm i\phi}$	
	$l=2$	$m=0$	$\psi_{420}=N_{420}\rho^2(6-\rho)e^{-\frac{1}{2}\rho}(3\cos^2\theta-1)$	$4d^5$
		$m=\pm1$	$\psi_{42\pm1}=N_{421}\rho^2(6-\rho)e^{-\frac{1}{2}\rho}\,\mathrm{sen}\,\theta\cos\theta\, e^{\pm i\phi}$	
		$m=\pm2$	$\psi_{42\pm2}=N_{422}\rho^2(6-\rho)e^{-\frac{1}{2}\rho}\,\mathrm{sen}^2\theta\, e^{\pm 2i\phi}$	
	$l=3$	$m=0$	$\psi_{430}=N_{430}\rho^3e^{-\frac{1}{2}\rho}(\frac{5}{3}\cos^3\theta-\cos\theta)$	$4f^7$
		$m=\pm1$	$\psi_{43\pm1}=N_{431}\rho^3e^{-\frac{1}{2}\rho}(5\cos^2\theta-1)\,\mathrm{sen}\,\theta\, e^{\pm i\phi}$	
(16 estados)		$m=\pm2$	$\psi_{43\pm2}=N_{432}\rho^3e^{-\frac{1}{2}\rho}\,\mathrm{sen}^2\theta\cos\theta\, e^{\pm 2i\phi}$	
		$m=\pm3$	$\psi_{43\pm3}=N_{433}\rho^3e^{-\frac{1}{2}\rho}\,\mathrm{sen}^3\theta\, e^{\pm 3i\phi}$	

$$N_{nlm}=-\left[\left(\frac{2m_0e^2}{n\hbar^2}\right)^3\frac{(n-l-1)!(l-m)!(2l+1)}{4\pi(2n[n+l]!)^3(l+m)!}\right]^{1/2}$$

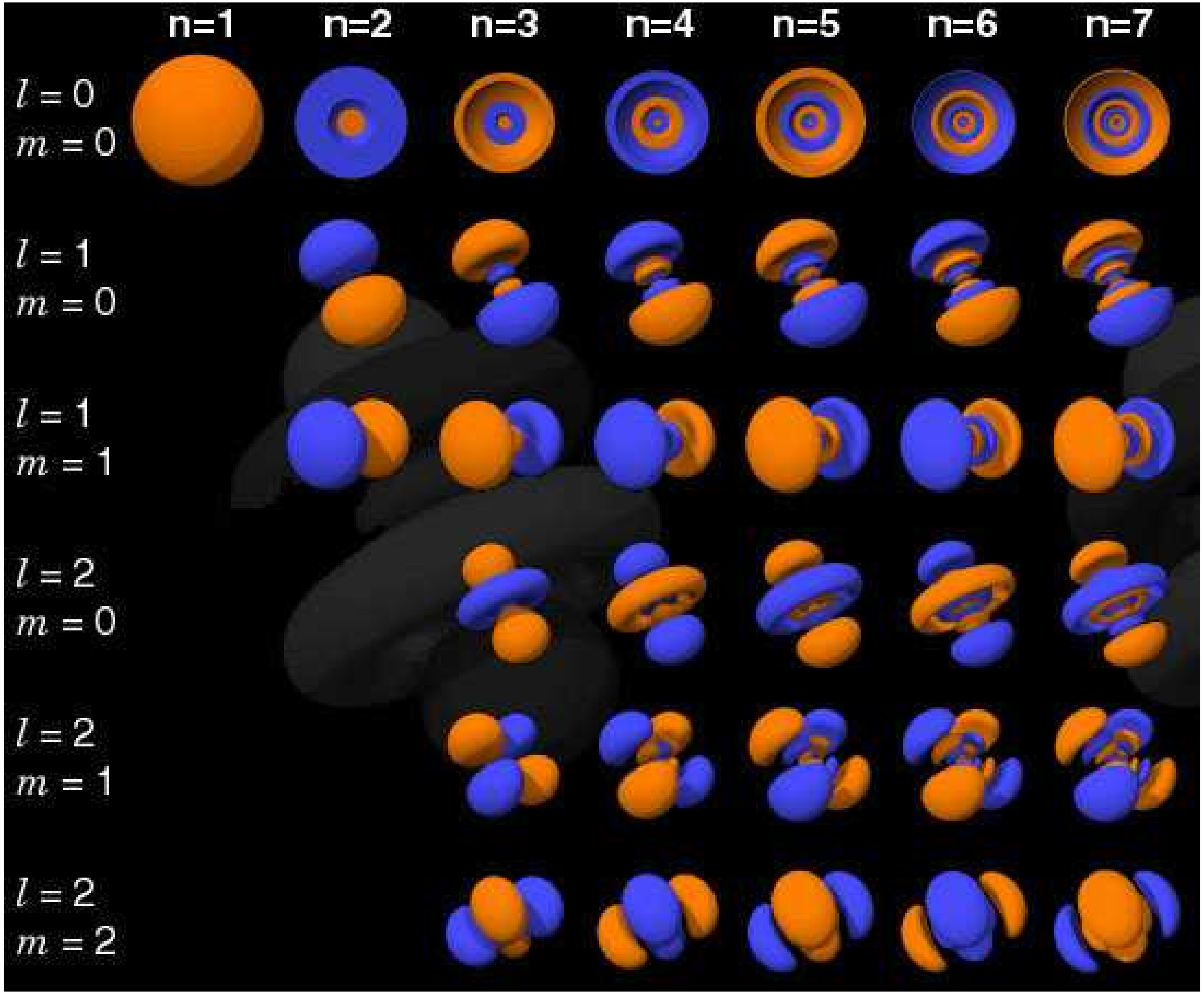


n = 1 :: l = 0
n = 2 :: l = 0
n = 3 :: l = 0
n = 4 :: l = 0
1s
2s
3s
4s
0.6
0.5
0.4
0.3
0.2
0.1
0
0 4 8 12 16 20 24 28
n = 2 :: l = 1
n = 3 :: l = 1
n = 4 :: l = 1
2p
3p
4p
0.20
0.16
0.12
0.08
0.04
0
0 4 8 12 16 20 24 28



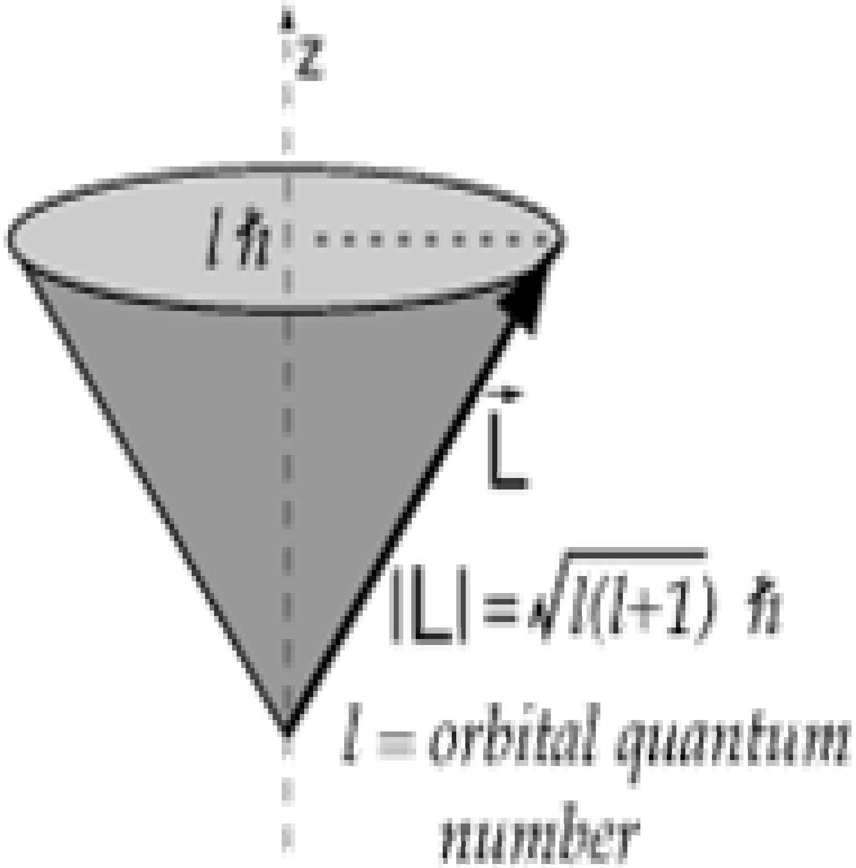
n = 1, l = m_l = 0
n = 2, l = m_l = 0
n = 2, l = 1, m_l = ±1
n = 2, l = 1, m_l = 0
n = 3, l = 2, m_l = ±2
n = 3, l = 1, m_l = ±1
n = 3, l = m_l = 0
n = 3, l = 2, m_l = ±1
n = 3, l = 1, m_l = 0

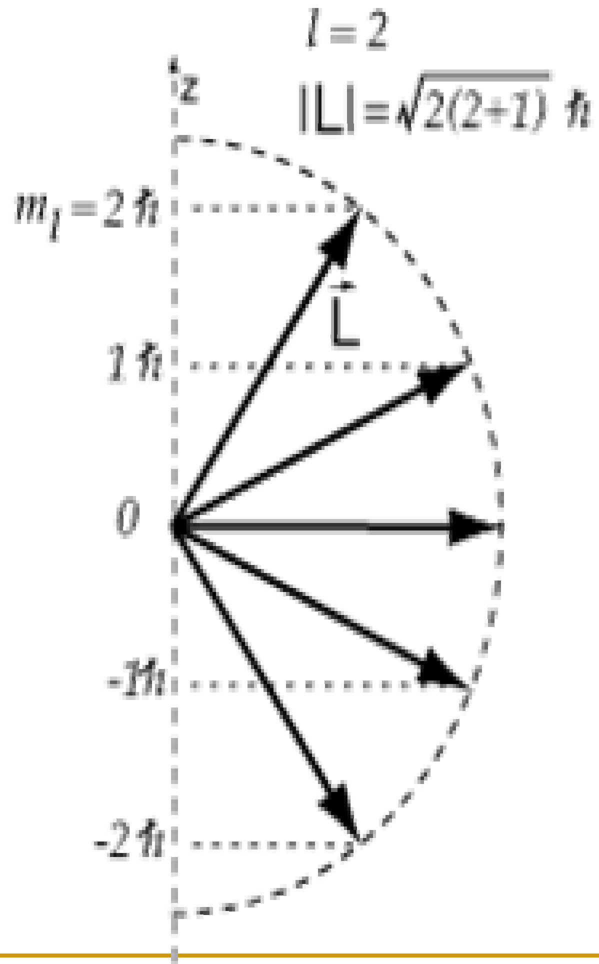
n = 3 :: l = 1



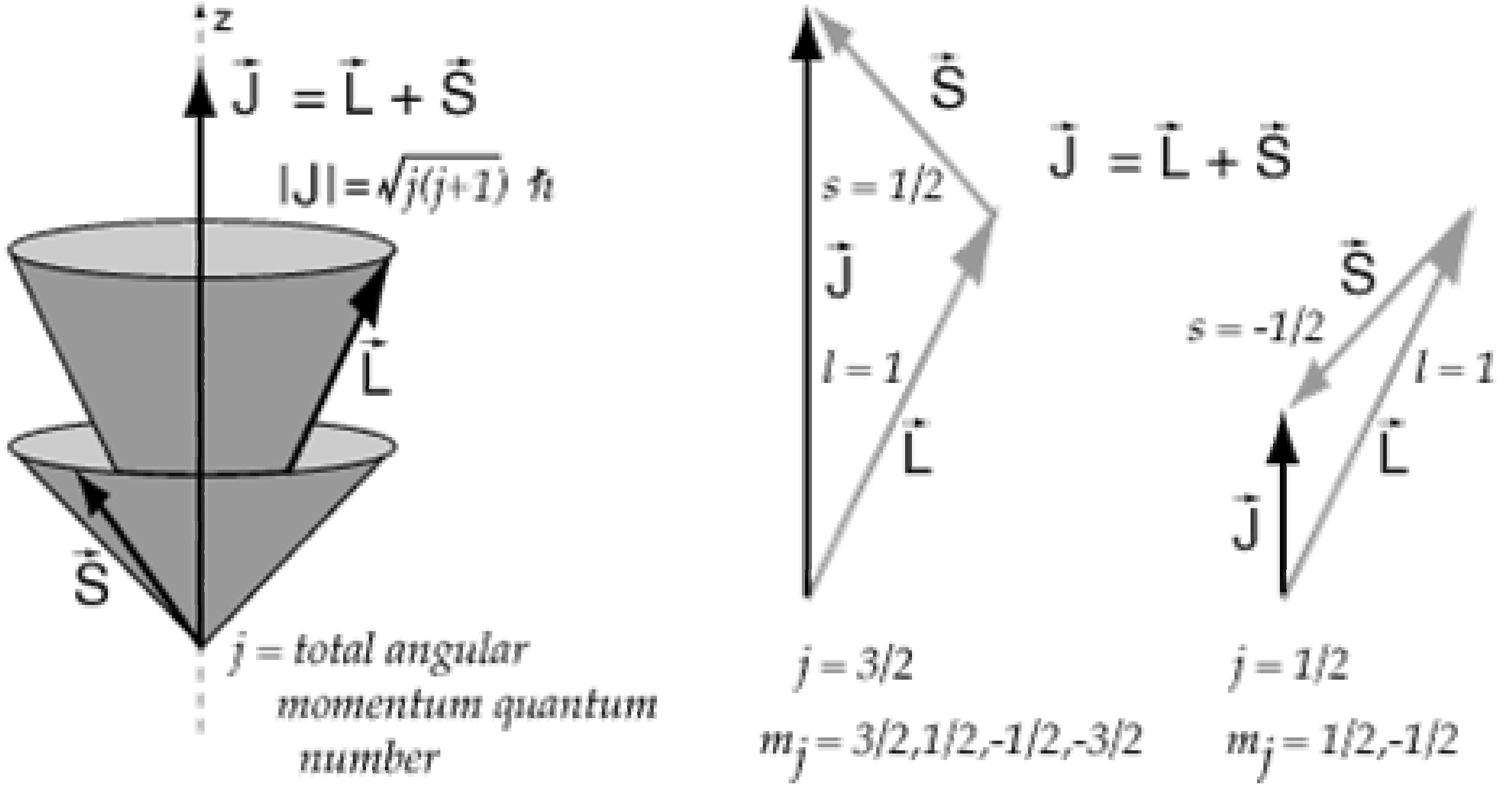
n=1
n=2
n=3
n=4
n=5
n=6
n=7
$l = 0$ $m = 0$
$l = 1$ $m = 0$
$l = 1$ $m = 1$
$l = 2$ $m = 0$
$l = 2$ $m = 1$
$l = 2$ $m = 2$

Momento orbital magnético

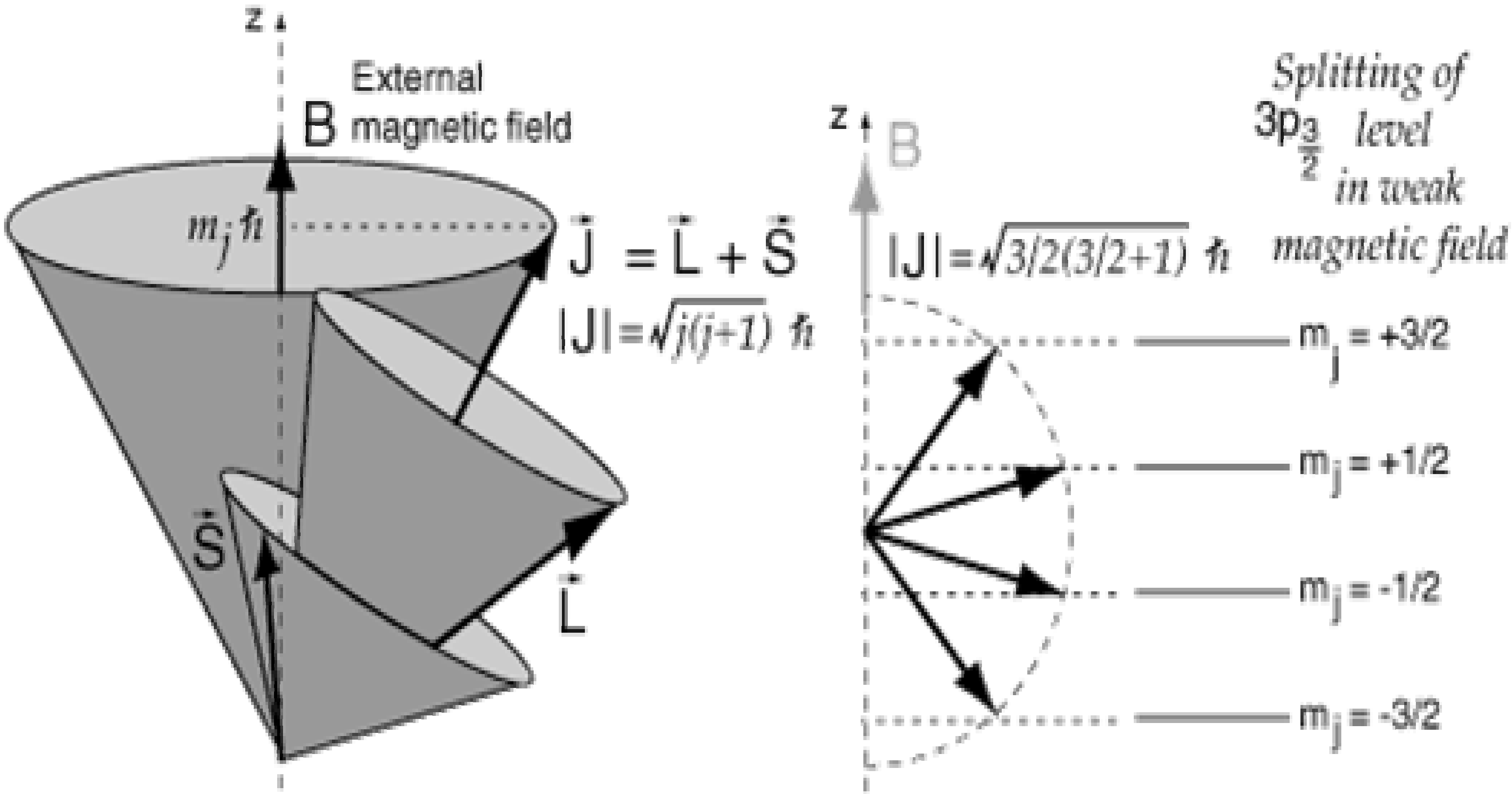




Momento orbital total



Momento orbital total



n = 1 :: 2 e^-

n = 2 :: (2+6) e^-

n = 3 :: (2+6+10) e^-

TABLA 4.2.

Configuraciones electrónicas y el sistem

1s	H	$1s$
	He	$1s^2)$
2s	Li	$1s^2)2s$
	Be	$1s^2)2s^2$
	B	$1s^2)2s^22p$
	C	$1s^2)2s^22p^2$
	N	$1s^2)2s^22p^3$
	O	$1s^2)2s^22p^4$
	F	$1s^2)2s^22p^5$
	Ne	$1s^2)2s^22p^6)$
3s	Na	$1s^2)2s^22p^6)3s$
	Mg	$1s^2)2s^22p^6)3s^2$
3p	Al	$1s^2)2s^22p^6)3s^23p$
	Si	$1s^2)2s^22p^6)3s^23p^2$
	P	$1s^2)2s^22p^6)3s^23p^3$
	S	$1s^2)2s^22p^6)3s^23p^4$
	Cl	$1s^2)2s^22p^6)3s^23p^5$
	A	$1s^2)2s^22p^6)3s^23p^6)$
4s	K	$1s^2)2s^22p^6)3s^23p^6)4s$
	Ca	$1s^2)2s^22p^6)3s^23p^6)4s^2$
3d	Sc	$1s^2)2s^22p^6)3s^23p^63d)4s^2$
	Ti	$1s^2)2s^22p^6)3s^23p^63d^2)4s^2$

Nivel n=2 completo

No se sigue completando el nivel n=3

TABLA 4.2.
Configuraciones electrónicas y el sistem

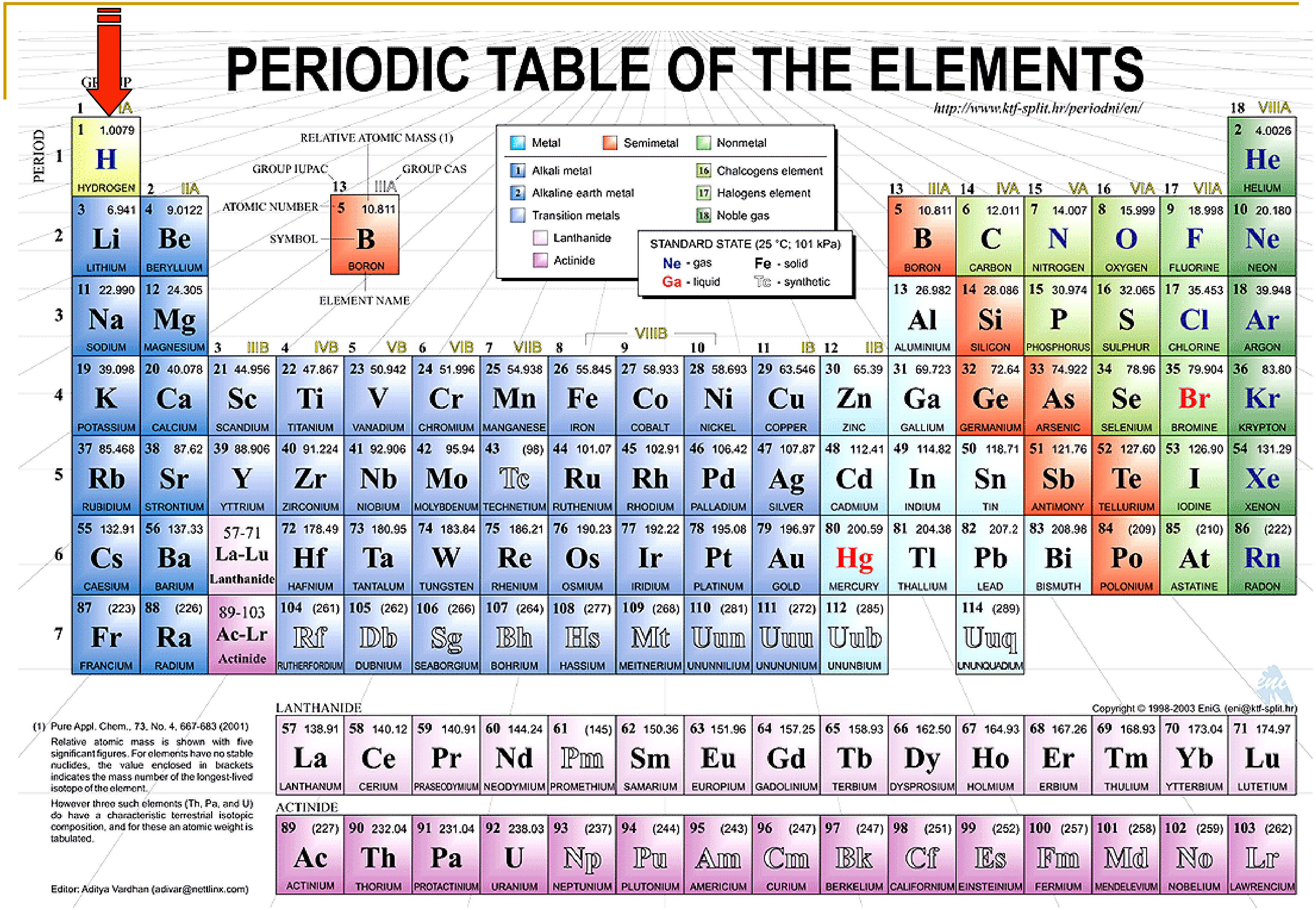
$1s$	H	$1s$
	He	$1s^2)$
$2s$	Li	$1s^2)2s$
	Be	$1s^2)2s^2$
	B	$1s^2)2s^22p$
	C	$1s^2)2s^22p^2$
	N	$1s^2)2s^22p^3$
	O	$1s^2)2s^22p^4$
	F	$1s^2)2s^22p^5$
	Ne	$1s^2)2s^22p^6)$
$3s$	Na	$1s^2)2s^22p^6)3s$
	Mg	$1s^2)2s^22p^6)3s^2$
$3p$	Al	$1s^2)2s^22p^6)3s^23p$
	Si	$1s^2)2s^22p^6)3s^23p^2$
	P	$1s^2)2s^22p^6)3s^23p^3$
	S	$1s^2)2s^22p^6)3s^23p^4$
	Cl	$1s^2)2s^22p^6)3s^23p^5$
	A	$1s^2)2s^22p^6)3s^23p^6)$
$4s$	K	$1s^2)2s^22p^6)3s^23p^6)4s$
	Ca	$1s^2)2s^22p^6)3s^23p^6)4s^2$
$3d$	Sc	$1s^2)2s^22p^6)3s^23p^63d)4s^2$
	Ti	$1s^2)2s^22p^6)3s^23p^63d^2)4s^2$

H 1s

Li 2s

Na 3s

K 4s


PERIODIC TABLE OF THE ELEMENTS
http://www.ktf-split.hr/periodni/en/
GROUP
PERIOD
RELATIVE ATOMIC MASS (1)
GROUP IUPAC
GROUP CAS
ATOMIC NUMBER
SYMBOL
ELEMENT NAME
5 10.811 B BORON
Metal
Semimetal
Nonmetal
Alkali metal
Alkaline earth metal
Transition metals
Lanthanide
Actinide
Chalcogens element
Halogens element
Noble gas
STANDARD STATE (25 °C; 101 kPa)
Ne - gas
Fe - solid
Ga - liquid
Tc - synthetic
1 IA
2 IIA
3 IIIB
4 IVB
5 VB
6 VIB
7 VIIB
8 9 10 VIIIB
11 IB
12 IIB
13 IIIA
14 IVA
15 VA
16 VIA
17 VIIA
18 VIIIA
1 1.0079 H HYDROGEN
2 4.0026 He HELIUM
3 6.941 Li LITHIUM
4 9.0122 Be BERYLLIUM
5 10.811 B BORON
6 12.011 C CARBON
7 14.007 N NITROGEN
8 15.999 O OXYGEN
9 18.998 F FLUORINE
10 20.180 Ne NEON
11 22.990 Na SODIUM
12 24.305 Mg MAGNESIUM
13 26.982 Al ALUMINIUM
14 28.086 Si SILICON
15 30.974 P PHOSPHORUS
16 32.065 S SULPHUR
17 35.453 Cl CHLORINE
18 39.948 Ar ARGON
19 39.098 K POTASSIUM
20 40.078 Ca CALCIUM
21 44.956 Sc SCANDIUM
22 47.867 Ti TITANIUM
23 50.942 V VANADIUM
24 51.996 Cr CHROMIUM
25 54.938 Mn MANGANESE
26 55.845 Fe IRON
27 58.933 Co COBALT
28 58.693 Ni NICKEL
29 63.546 Cu COPPER
30 65.39 Zn ZINC
31 69.723 Ga GALLIUM
32 72.64 Ge GERMANIUM
33 74.922 As ARSENIC
34 78.96 Se SELENIUM
35 79.904 Br BROMINE
36 83.80 Kr KRYPTON
37 85.468 Rb RUBIDIUM
38 87.62 Sr STRONTIUM
39 88.906 Y YTTRIUM
40 91.224 Zr ZIRCONIUM
41 92.906 Nb NIOBIUM
42 95.94 Mo MOLYBDENUM
43 (98) Tc TECHNETIUM
44 101.07 Ru RUTHENIUM
45 102.91 Rh RHODIUM
46 106.42 Pd PALLADIUM
47 107.87 Ag SILVER
48 112.41 Cd CADMIUM
49 114.82 In INDIUM
50 118.71 Sn TIN
51 121.76 Sb ANTIMONY
52 127.60 Te TELLURIUM
53 126.90 I IODINE
54 131.29 Xe XENON
55 132.91 Cs CAESIUM
56 137.33 Ba BARIUM
57-71 La-Lu Lanthanide
72 178.49 Hf HAFNIUM
73 180.95 Ta TANTALUM
74 183.84 W TUNGSTEN
75 186.21 Re RHENIUM
76 190.23 Os OSMIUM
77 192.22 Ir IRIDIUM
78 195.08 Pt PLATINUM
79 196.97 Au GOLD
80 200.59 Hg MERCURY
81 204.38 Tl THALLIUM
82 207.2 Pb LEAD
83 208.98 Bi BISMUTH
84 (209) Po POLONIUM
85 (210) At ASTATINE
86 (222) Rn RADON
87 (223) Fr FRANCIUM
88 (226) Ra RADIUM
89-103 Ac-Lr Actinide
104 (261) Rf RUTHERFORDIUM
105 (262) Db DUBNIUM
106 (266) Sg SEABORGIUM
107 (264) Bh BOHRIUM
108 (277) Hs HASSIUM
109 (268) Mt MEITNERIUM
110 (281) Uun UNUNNILIUM
111 (272) Uuu UNUNUNIUM
112 (285) Uub UNUNBIUM
114 (289) Uuq UNUNQUADIUM
LANTHANIDE
57 138.91 La LANTHANUM
58 140.12 Ce CERIUM
59 140.91 Pr PRASEODYMIUM
60 144.24 Nd NEODYMIUM
61 (145) Pm PROMETHIUM
62 150.36 Sm SAMARIUM
63 151.96 Eu EUROPIUM
64 157.25 Gd GADOLINIUM
65 158.93 Tb TERBIUM
66 162.50 Dy DYSPROSIUM
67 164.93 Ho HOLMIUM
68 167.26 Er ERBIUM
69 168.93 Tm THULIUM
70 173.04 Yb YTTERBIUM
71 174.97 Lu LUTETIUM
ACTINIDE
89 (227) Ac ACTINIUM
90 232.04 Th THORIUM
91 231.04 Pa PROTACTINIUM
92 238.03 U URANIUM
93 (237) Np NEPTUNIUM
94 (244) Pu PLUTONIUM
95 (243) Am AMERICIUM
96 (247) Cm CURIUM
97 (247) Bk BERKELIUM
98 (251) Cf CALIFORNIUM
99 (252) Es EINSTEINIUM
100 (257) Fm FERMIUM
101 (258) Md MENDELEVIUM
102 (259) No NOBELIUM
103 (262) Lr LAWRENCIUM
(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.
Editor: Aditya Vardhan (adivar@nettlinx.com)
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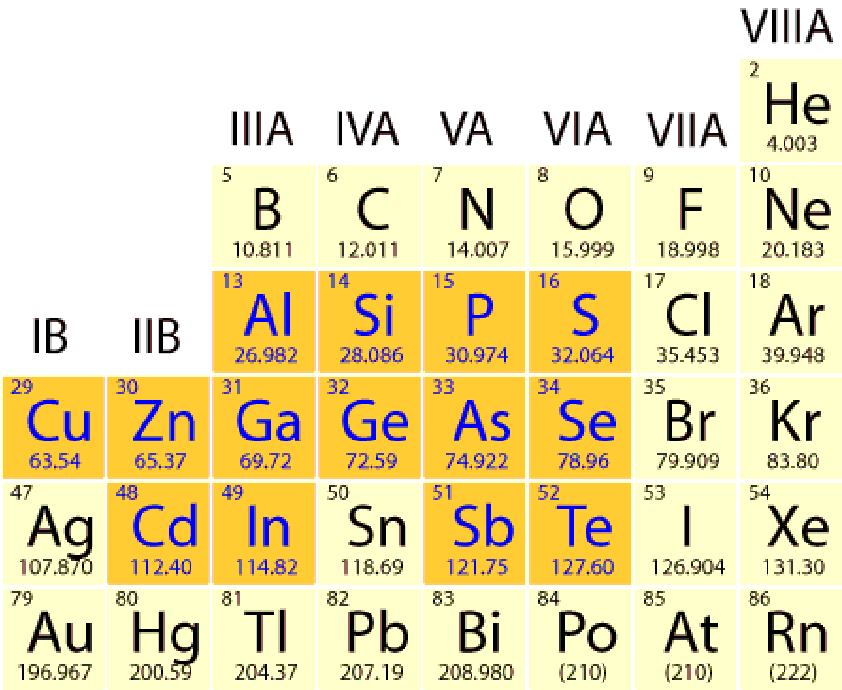
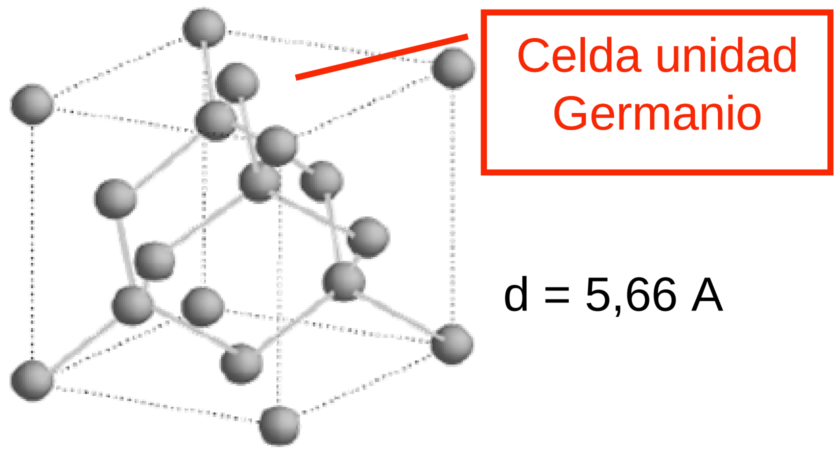
Semiconductores

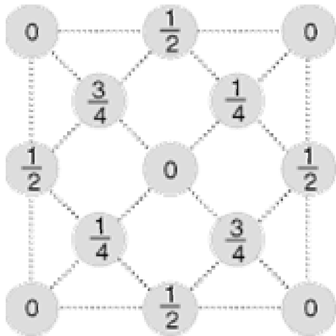
Ge :: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^2$

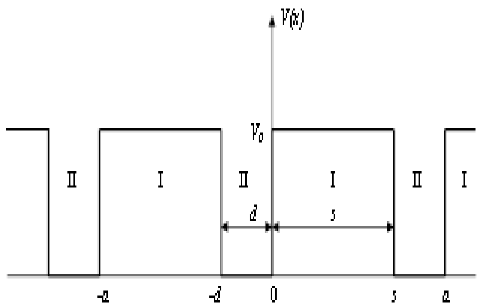


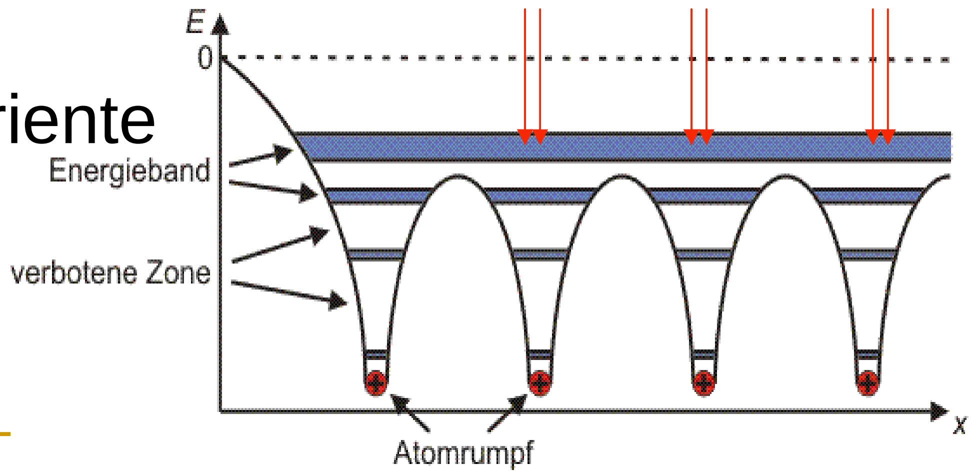
Próximamente...



- Ec. Schrödinger para Potencial periódico.
- Modelo de Kronig-Penney.
- ✓ Potencial periódico 1D.
- ✓ Bandas de energía permitidas.
- ✓ Bandas de energía prohibidas.
- ✓ Conducción de la corriente en las bandas.







Bandas de energía en el diamante.