

# A periódusos rendszer, periodikus tulajdonságok

---

Szalai István

ELTE Kémiai Intézet

# Az előadás vázlata

- Ismétlés
- Történeti áttekintés
- Mengyelejev periódusos rendszere
- Atomsugár, ionsugár
- Ionizációs energia
- Elektronaffinitás
- Elektronegativitás
- Kémiai tulajdonságok periodikus változása
- Összefoglalás

# Elektronszerkezet (ismétlés)

- A mag körül olyan elektronokszerkezet alakul ki, amelynél az atom energiája a lehető legkisebb.
- Pauli-elv: Az atomon belül nem lehet két olyan elektron, amelynek minden kvantumszáma megegyezne.
- Hund szabály: az alhéjak olyan módon töltődnek fel, hogy minél nagyobb legyen a párosítatlan elektronok száma.
- A legtöbb esetben a beépülés növekvő  $(n + l)$  értékek szerint megy végbe.

# Dmitrij Mengyeljev (1837-1907)



1869-ben publikálja elgondolását a periódusos rendszerről:

- „Az atomsúlyaik nagysága szerint elrendezett elemek jól érzékelhetően periodikus tulajdonságokat mutatnak.”
- „Az elemek atomsúlyok alapján rendezett csoportjai meghatározzák a vegyértéket és bizonyos fokig a kémiai jellemzők különbségeit is. Ez a jelenség jól érzékelhető a Li, Be, B, C, N, O, F csoportban, és megismétlődik a többi csoportban.”
- „Arra kell számítanunk, hogy sok ismeretlen testet fedeznek



# Dmitrij Mengyeljev (1837-1907)

## ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ВѢСЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

		Ti=50	Zr=90	?=180.
		V=51	Nb=94	Ta=182.
		Cr=52	Mo=96	W=186.
		Mn=55	Rh=104,4	Pt=197,4
		Fe=56	Rn=104,4	Ir=198.
		Ni=Co=59	Pi=106,4	O=199.
H=1		Cu=63,4	Ag=108	Hg=200.
Be=9,4	Mg=24	Zn=65,2	Cd=112	
B=11	Al=27,4	?=68	Ur=116	Au=197?
C=12	Si=28	?=70	Sn=118	
N=14	P=31	As=75	Sb=122	Bi=210?
O=16	S=32	Se=79,4	Te=128?	
F=19	Cl=35,4	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133
		Ca=40	Sr=87,4	Ba=137
		?=45	Ce=92	Pb=207.
		?Er=56	La=94	
		?Yt=60	Di=95	
		?In=75,4	Th=118?	

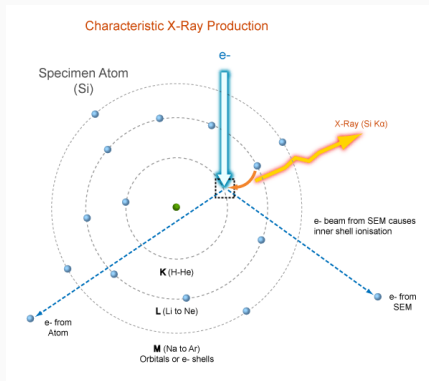
Д. Менделѣевъ

# Hiányzó elemek

Tulajdonság	Mengyelejev jóslata	Mért tulajdonságok
	ekaaluminium	gallium
Atomtömeg	72	72,6
Sűrűség	5,5 g/cm <sup>3</sup>	5,35 g/cm <sup>3</sup>
Oxidjának képlete	X <sub>2</sub> O <sub>3</sub>	Ga <sub>2</sub> O <sub>3</sub>
	ekaszilícium	germánium
Atomtömeg	68	69,72
Sűrűség	6,0 g/cm <sup>3</sup>	5,9 g/cm <sup>3</sup>
Oxidjának képlete	XO <sub>2</sub>	GeO <sub>2</sub>

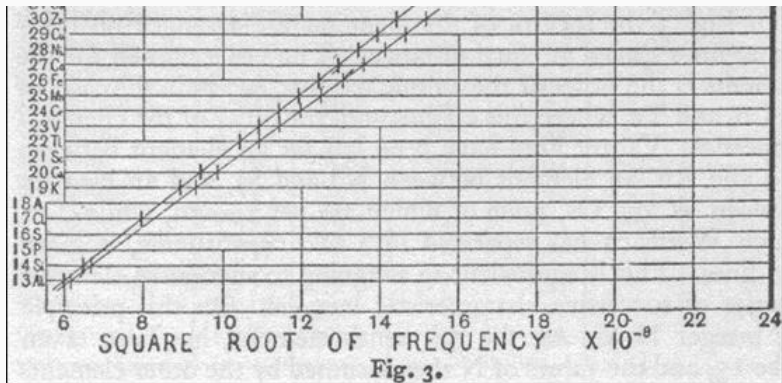
# A periódusos rendszer fejlődése

Moseley (1914): összefüggés a rendszám és a röntgensugárzás ( $K_{\alpha}$ ) hullámhossza között ( $\sqrt{f} = k_1(Z - k_2)$ )



# A periódusos rendszer fejlődése

Moseley (1914): összefüggés a rendszám és a röntgensugárzás ( $K_\alpha$ ) hullámhossza között ( $\sqrt{f} = k_1(Z - k_2)$ )



Következmény: helycserék: Co( $A_r$  : 58,9;  $Z = 27$ )-Ni( $A_r$  : 58,7;  $Z = 28$ ), új elemek Tc, Pm.

# A periódusos rendszer (IUPAC 2012)

1 <b>H</b> hydrogen (1.007, 1.008)																	18 <b>He</b> helium 4.003						
3 <b>Li</b> lithium (6.941, 6.957)	4 <b>Be</b> beryllium 9.012																	6 <b>C</b> carbon (12.010, 12.011)	7 <b>N</b> nitrogen (14.006, 14.007)	8 <b>O</b> oxygen (15.999, 16.003)	9 <b>F</b> fluorine 18.998	10 <b>Ne</b> neon 20.180	
11 <b>Na</b> sodium 22.990	12 <b>Mg</b> magnesium 24.305																	13 <b>Al</b> aluminium 26.982	14 <b>Si</b> silicon (28.085, 28.086)	15 <b>P</b> phosphorus 30.974	16 <b>S</b> sulfur (32.059, 32.061)	17 <b>Cl</b> chlorine (35.446, 35.453)	18 <b>Ar</b> argon 39.948
19 <b>K</b> potassium 39.098	20 <b>Ca</b> calcium 40.078	21 <b>Sc</b> scandium 44.956	22 <b>Ti</b> titanium 47.867	23 <b>V</b> vanadium 50.942	24 <b>Cr</b> chromium 51.996	25 <b>Mn</b> manganese 54.938	26 <b>Fe</b> iron 55.845	27 <b>Co</b> cobalt 58.933	28 <b>Ni</b> nickel 58.693	29 <b>Cu</b> copper 63.546	30 <b>Zn</b> zinc 65.38	31 <b>Ga</b> gallium 69.723	32 <b>Ge</b> germanium 72.630	33 <b>As</b> arsenic 74.922	34 <b>Se</b> selenium 78.96	35 <b>Br</b> bromine 79.904	36 <b>Kr</b> krypton 83.80						
37 <b>Rb</b> rubidium 85.468	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.906	40 <b>Zr</b> zirconium 91.224	41 <b>Nb</b> niobium 92.906	42 <b>Mo</b> molybdenum 95.94	43 <b>Tc</b> technetium 98	44 <b>Ru</b> ruthenium 101.07	45 <b>Rh</b> rhodium 102.905	46 <b>Pd</b> palladium 106.42	47 <b>Ag</b> silver 107.868	48 <b>Cd</b> cadmium 112.411	49 <b>In</b> indium 114.818	50 <b>Sn</b> tin 118.710	51 <b>Sb</b> antimony 121.757	52 <b>Te</b> tellurium 127.6	53 <b>I</b> iodine 126.905	54 <b>Xe</b> xenon 131.29						
55 <b>Cs</b> caesium 132.905	56 <b>Ba</b> barium 137.327	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.49	73 <b>Ta</b> tantalum 180.948	74 <b>W</b> tungsten 183.84	75 <b>Re</b> rhenium 186.207	76 <b>Os</b> osmium 190.23	77 <b>Ir</b> iridium 192.222	78 <b>Pt</b> platinum 195.084	79 <b>Au</b> gold 196.967	80 <b>Hg</b> mercury 200.59	81 <b>Tl</b> thallium (204.38, 204.4)	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 208.98	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon						
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium										
57 <b>La</b> lanthanum 138.905	58 <b>Ce</b> cerium 140.12	59 <b>Pr</b> praseodymium 140.908	60 <b>Nd</b> neodymium 144.24	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.41	63 <b>Eu</b> europium 151.964	64 <b>Gd</b> gadolinium 157.25	65 <b>Tb</b> terbium 158.925	66 <b>Dy</b> dysprosium 162.5	67 <b>Ho</b> holmium 164.930	68 <b>Er</b> erbium 167.259	69 <b>Tm</b> thulium 168.934	70 <b>Yb</b> ytterbium 173.054	71 <b>Lu</b> lutetium 174.967									
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.037	91 <b>Pa</b> protactinium 231.036	92 <b>U</b> uranium 238.029	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium									

# A periódusos rendszer (IUPAC 2012)

## Alkálifémek $ns^1$

1 <b>H</b> hydrogen (1.007, 1.008)																	18 <b>He</b> helium 4.003	
3 <b>Li</b> lithium (6.941, 6.967)	4 <b>Be</b> beryllium 9.012																	10 <b>Ne</b> neon 20.18
11 <b>Na</b> sodium 22.99	12 <b>Mg</b> magnesium 24.31																	18 <b>Ar</b> argon 39.95
19 <b>K</b> potassium 39.10	20 <b>Ca</b> calcium 40.08	21 <b>Sc</b> scandium 44.96	22 <b>Ti</b> titanium 47.87	23 <b>V</b> vanadium 50.94	24 <b>Cr</b> chromium 52.00	25 <b>Mn</b> manganese 54.94	26 <b>Fe</b> iron 55.85	27 <b>Co</b> cobalt 58.93	28 <b>Ni</b> nickel 58.69	29 <b>Cu</b> copper 63.55	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.72	32 <b>Ge</b> germanium 72.63	33 <b>As</b> arsenic 74.92	34 <b>Se</b> selenium 78.96(3)	35 <b>Br</b> bromine 79.90	36 <b>Kr</b> krypton 83.80	
37 <b>Rb</b> rubidium 85.47	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.91	40 <b>Zr</b> zirconium 91.22	41 <b>Nb</b> niobium 92.91	42 <b>Mo</b> molybdenum 95.94(2)	43 <b>Tc</b> technetium 98.91	44 <b>Ru</b> ruthenium 101.1	45 <b>Rh</b> rhodium 102.9	46 <b>Pd</b> palladium 106.4	47 <b>Ag</b> silver 107.9	48 <b>Cd</b> cadmium 112.4	49 <b>In</b> indium 114.8	50 <b>Sn</b> tin 118.7	51 <b>Sb</b> antimony 121.8	52 <b>Te</b> tellurium 127.6	53 <b>I</b> iodine 126.9	54 <b>Xe</b> xenon 131.3	
55 <b>Cs</b> caesium 132.9	56 <b>Ba</b> barium 137.3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.5	73 <b>Ta</b> tantalum 180.9	74 <b>W</b> tungsten 183.8	75 <b>Re</b> rhenium 186.2	76 <b>Os</b> osmium 192.2	77 <b>Ir</b> iridium 192.2	78 <b>Pt</b> platinum 195.1	79 <b>Au</b> gold 197.0	80 <b>Hg</b> mercury 200.6	81 <b>Tl</b> thallium (204.3, 204.4)	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 209.0	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138.9	58 <b>Ce</b> cerium 140.1	59 <b>Pr</b> praseodymium 140.9	60 <b>Nd</b> neodymium 144.2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.4	63 <b>Eu</b> europium 152.0	64 <b>Gd</b> gadolinium 157.3	65 <b>Tb</b> terbium 158.9	66 <b>Dy</b> dysprosium 162.5	67 <b>Ho</b> holmium 164.9	68 <b>Er</b> erbium 167.3	69 <b>Tm</b> thulium 168.9	70 <b>Yb</b> ytterbium 173.1	71 <b>Lu</b> lutetium 175.0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.0	91 <b>Pa</b> protactinium 231.0	92 <b>U</b> uranium 238.0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# A periódusos rendszer (IUPAC 2012)

## Alkáliföldfémek $ns^2$

1 <b>H</b> hydrogen (1.007, 1.008)																	18 <b>He</b> helium 4.003						
3 <b>Li</b> lithium (6.941, 6.957)	4 <b>Be</b> beryllium 9.012																	13 <b>B</b> boron (10.81, 10.83)	14 <b>C</b> carbon (12.01, 12.02)	15 <b>N</b> nitrogen (14.01, 14.01)	16 <b>O</b> oxygen (15.99, 16.00)	17 <b>F</b> fluorine 18.99	10 <b>Ne</b> neon 20.18
11 <b>Na</b> sodium 22.99	12 <b>Mg</b> magnesium 24.31																	13 <b>Al</b> aluminium 26.98	14 <b>Si</b> silicon (28.08, 28.09)	15 <b>P</b> phosphorus 30.97	16 <b>S</b> sulfur (32.01, 32.06)	17 <b>Cl</b> chlorine (35.44, 35.45)	18 <b>Ar</b> argon 39.95
19 <b>K</b> potassium 39.10	20 <b>Ca</b> calcium 40.08	21 <b>Sc</b> scandium 44.96	22 <b>Ti</b> titanium 47.87	23 <b>V</b> vanadium 50.94	24 <b>Cr</b> chromium 52.00	25 <b>Mn</b> manganese 54.94	26 <b>Fe</b> iron 55.85	27 <b>Co</b> cobalt 58.93	28 <b>Ni</b> nickel 58.69	29 <b>Cu</b> copper 63.55	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.72	32 <b>Ge</b> germanium 72.63	33 <b>As</b> arsenic 74.92	34 <b>Se</b> selenium 78.96(3)	35 <b>Br</b> bromine 79.90	36 <b>Kr</b> krypton 83.80						
37 <b>Rb</b> rubidium 85.47	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.91	40 <b>Zr</b> zirconium 91.22	41 <b>Nb</b> niobium 92.91	42 <b>Mo</b> molybdenum 95.94(2)	43 <b>Tc</b> technetium 98.91	44 <b>Ru</b> ruthenium 101.1	45 <b>Rh</b> rhodium 102.9	46 <b>Pd</b> palladium 106.4	47 <b>Ag</b> silver 107.9	48 <b>Cd</b> cadmium 112.4	49 <b>In</b> indium 114.8	50 <b>Sn</b> tin 118.7	51 <b>Sb</b> antimony 121.8	52 <b>Te</b> tellurium 127.6	53 <b>I</b> iodine 126.9	54 <b>Xe</b> xenon 131.3						
55 <b>Cs</b> caesium 132.9	56 <b>Ba</b> barium 137.3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.5	73 <b>Ta</b> tantalum 180.9	74 <b>W</b> tungsten 183.8	75 <b>Re</b> rhenium 186.2	76 <b>Os</b> osmium 192.2	77 <b>Ir</b> iridium 192.2	78 <b>Pt</b> platinum 195.1	79 <b>Au</b> gold 197.0	80 <b>Hg</b> mercury 200.6	81 <b>Tl</b> thallium (204.3, 204.4)	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 209.0	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon						
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium										
57 <b>La</b> lanthanum 138.9	58 <b>Ce</b> cerium 140.1	59 <b>Pr</b> praseodymium 140.9	60 <b>Nd</b> neodymium 144.2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.4	63 <b>Eu</b> europium 152.0	64 <b>Gd</b> gadolinium 157.3	65 <b>Tb</b> terbium 158.9	66 <b>Dy</b> dysprosium 162.5	67 <b>Ho</b> holmium 164.9	68 <b>Er</b> erbium 167.3	69 <b>Tm</b> thulium 168.9	70 <b>Yb</b> ytterbium 173.1	71 <b>Lu</b> lutetium 175.0									
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.0	91 <b>Pa</b> protactinium 231.0	92 <b>U</b> uranium 238.0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium									

# A periódusos rendszer (IUPAC 2012)

Átmenetifémek  $ns^2(n-1)d^{1-10}$

1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003															
3 <b>Li</b> lithium (6,941; 6,947)	4 <b>Be</b> beryllium 9,012											13 <b>B</b> boron (10,81; 10,83)	14 <b>C</b> carbon (12,01; 12,02)	15 <b>N</b> nitrogen (14,01; 14,01)	16 <b>O</b> oxygen (15,99; 16,00)	17 <b>F</b> fluorine 18,99	10 <b>Ne</b> neon 20,18															
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31											13 <b>Al</b> aluminium 26,98	14 <b>Si</b> silicon (28,08; 28,09)	15 <b>P</b> phosphorus 30,97	16 <b>S</b> sulfur (32,01; 32,06)	17 <b>Cl</b> chlorine (35,44; 35,45)	18 <b>Ar</b> argon 39,95															
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80															
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3															
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 197,0	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium (204,3; 204,4)	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 209,0	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon															
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium		116 <b>Lv</b> livermorium																		
																		57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0
																		89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium



# A periódusos rendszer (IUPAC 2012)

## Bórcsoport $ns^2np^1$

1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003	
3 <b>Li</b> lithium (6,941; 6,967)	4 <b>Be</b> beryllium 9,012																	10 <b>Ne</b> neon 20,18
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31																	18 <b>Ar</b> argon 39,95
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80	
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3	
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 196,9	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium 204,3, 204,4	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 208,9	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# A periódusos rendszer (IUPAC 2012)

## Szencsoport ( $ns^2 np^2$ )

1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003	
3 <b>Li</b> lithium (6,941; 6,967)	4 <b>Be</b> beryllium 9,012																	10 <b>Ne</b> neon 20,18
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31																	18 <b>Ar</b> argon 39,95
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80	
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3	
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 196,9	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium (204,3; 204,4)	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 208,9	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# A periódusos rendszer (IUPAC 2012)

## Nitrogéncsoport ( $ns^2 np^3$ )

1 <b>H</b> hydrogen (1.007, 1.008)																	18 <b>He</b> helium 4.003	
3 <b>Li</b> lithium (6.941, 6.957)	4 <b>Be</b> beryllium 9.012																	10 <b>Ne</b> neon 20.18
11 <b>Na</b> sodium 22.99	12 <b>Mg</b> magnesium 24.31																	18 <b>Ar</b> argon 39.95
19 <b>K</b> potassium 39.10	20 <b>Ca</b> calcium 40.08	21 <b>Sc</b> scandium 44.96	22 <b>Ti</b> titanium 47.87	23 <b>V</b> vanadium 50.94	24 <b>Cr</b> chromium 52.00	25 <b>Mn</b> manganese 54.94	26 <b>Fe</b> iron 55.85	27 <b>Co</b> cobalt 58.93	28 <b>Ni</b> nickel 58.69	29 <b>Cu</b> copper 63.55	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.72	32 <b>Ge</b> germanium 72.63	33 <b>As</b> arsenic 74.92	34 <b>Se</b> selenium 78.96(3)	35 <b>Br</b> bromine 79.90	36 <b>Kr</b> krypton 83.80	
37 <b>Rb</b> rubidium 85.47	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.91	40 <b>Zr</b> zirconium 91.22	41 <b>Nb</b> niobium 92.91	42 <b>Mo</b> molybdenum 95.94(2)	43 <b>Tc</b> technetium 98.91	44 <b>Ru</b> ruthenium 101.1	45 <b>Rh</b> rhodium 102.9	46 <b>Pd</b> palladium 106.4	47 <b>Ag</b> silver 107.9	48 <b>Cd</b> cadmium 112.4	49 <b>In</b> indium 114.8	50 <b>Sn</b> tin 118.7	51 <b>Sb</b> antimony 121.8	52 <b>Te</b> tellurium 127.6	53 <b>I</b> iodine 126.9	54 <b>Xe</b> xenon 131.3	
55 <b>Cs</b> caesium 132.9	56 <b>Ba</b> barium 137.3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.5	73 <b>Ta</b> tantalum 180.9	74 <b>W</b> tungsten 183.8	75 <b>Re</b> rhenium 186.2	76 <b>Os</b> osmium 190.2	77 <b>Ir</b> iridium 192.2	78 <b>Pt</b> platinum 195.1	79 <b>Au</b> gold 197.0	80 <b>Hg</b> mercury 200.6	81 <b>Tl</b> thallium (204.3, 204.4)	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 208.0	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138.9	58 <b>Ce</b> cerium 140.1	59 <b>Pr</b> praseodymium 140.9	60 <b>Nd</b> neodymium 144.2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.4	63 <b>Eu</b> europium 152.0	64 <b>Gd</b> gadolinium 157.3	65 <b>Tb</b> terbium 158.9	66 <b>Dy</b> dysprosium 162.5	67 <b>Ho</b> holmium 164.9	68 <b>Er</b> erbium 167.3	69 <b>Tm</b> thulium 168.9	70 <b>Yb</b> ytterbium 173.1	71 <b>Lu</b> lutetium 175.0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.0	91 <b>Pa</b> protactinium 231.0	92 <b>U</b> uranium 238.0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# A periódusos rendszer (IUPAC 2012)

## Oxigéncsoport ( $ns^2 np^4$ )

1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003	
3 <b>Li</b> lithium (6,941; 6,972)	4 <b>Be</b> beryllium 9,012																	10 <b>Ne</b> neon 20,18
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31																	18 <b>Ar</b> argon 39,95
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80	
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3	
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 196,9	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium (204,3; 204,4)	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 208,9	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# A periódusos rendszer (IUPAC 2012)

## Halogének ( $ns^2 np^5$ )

1 <b>H</b> hydrogen (1.007, 1.008)																	18 <b>He</b> helium 4.003
3 <b>Li</b> lithium (6.941, 6.957)	4 <b>Be</b> beryllium 9.012											5 <b>B</b> boron (10.81, 10.83)	6 <b>C</b> carbon (12.01, 12.02)	7 <b>N</b> nitrogen (14.01, 14.01)	8 <b>O</b> oxygen (16.00, 16.00)	9 <b>F</b> fluorine 18.99	10 <b>Ne</b> neon 20.18
11 <b>Na</b> sodium 22.99	12 <b>Mg</b> magnesium 24.31											13 <b>Al</b> aluminum 26.98	14 <b>Si</b> silicon (28.08, 28.09)	15 <b>P</b> phosphorus 30.97	16 <b>S</b> sulfur (32.01, 32.06)	17 <b>Cl</b> chlorine (35.44, 35.45)	18 <b>Ar</b> argon 39.95
19 <b>K</b> potassium 39.10	20 <b>Ca</b> calcium 40.08	21 <b>Sc</b> scandium 44.96	22 <b>Ti</b> titanium 47.87	23 <b>V</b> vanadium 50.94	24 <b>Cr</b> chromium 52.00	25 <b>Mn</b> manganese 54.94	26 <b>Fe</b> iron 55.85	27 <b>Co</b> cobalt 58.93	28 <b>Ni</b> nickel 58.69	29 <b>Cu</b> copper 63.55	30 <b>Zn</b> zinc 65.38(2)	31 <b>Ga</b> gallium 69.72	32 <b>Ge</b> germanium 72.63	33 <b>As</b> arsenic 74.92	34 <b>Se</b> selenium 78.96(3)	35 <b>Br</b> bromine 79.90	36 <b>Kr</b> krypton 83.80
37 <b>Rb</b> rubidium 85.47	38 <b>Sr</b> strontium 87.62	39 <b>Y</b> yttrium 88.91	40 <b>Zr</b> zirconium 91.22	41 <b>Nb</b> niobium 92.91	42 <b>Mo</b> molybdenum 95.94(2)	43 <b>Tc</b> technetium 98.91	44 <b>Ru</b> ruthenium 101.1	45 <b>Rh</b> rhodium 102.9	46 <b>Pd</b> palladium 106.4	47 <b>Ag</b> silver 107.9	48 <b>Cd</b> cadmium 112.4	49 <b>In</b> indium 114.8	50 <b>Sn</b> tin 118.7	51 <b>Sb</b> antimony 121.8	52 <b>Te</b> tellurium 127.6	53 <b>I</b> iodine 126.9	54 <b>Xe</b> xenon 131.3
55 <b>Cs</b> caesium 132.9	56 <b>Ba</b> barium 137.3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178.5	73 <b>Ta</b> tantalum 180.9	74 <b>W</b> tungsten 183.8	75 <b>Re</b> rhenium 186.2	76 <b>Os</b> osmium 190.2	77 <b>Ir</b> iridium 192.2	78 <b>Pt</b> platinum 195.1	79 <b>Au</b> gold 196.9	80 <b>Hg</b> mercury 200.6	81 <b>Tl</b> thallium (204.3, 204.4)	82 <b>Pb</b> lead 207.2	83 <b>Bi</b> bismuth 208.9	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium				
57 <b>La</b> lanthanum 138.9	58 <b>Ce</b> cerium 140.1	59 <b>Pr</b> praseodymium 140.9	60 <b>Nd</b> neodymium 144.2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150.4	63 <b>Eu</b> europium 152.0	64 <b>Gd</b> gadolinium 157.3	65 <b>Tb</b> terbium 158.9	66 <b>Dy</b> dysprosium 162.5	67 <b>Ho</b> holmium 164.9	68 <b>Er</b> erbium 167.3	69 <b>Tm</b> thulium 168.9	70 <b>Yb</b> ytterbium 173.1	71 <b>Lu</b> lutetium 175.0			
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232.0	91 <b>Pa</b> protactinium 231.0	92 <b>U</b> uranium 238.0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium			

# A periódusos rendszer (IUPAC 2012)

## Nemesgázok ( $ns^2np^6, 1s^2$ )

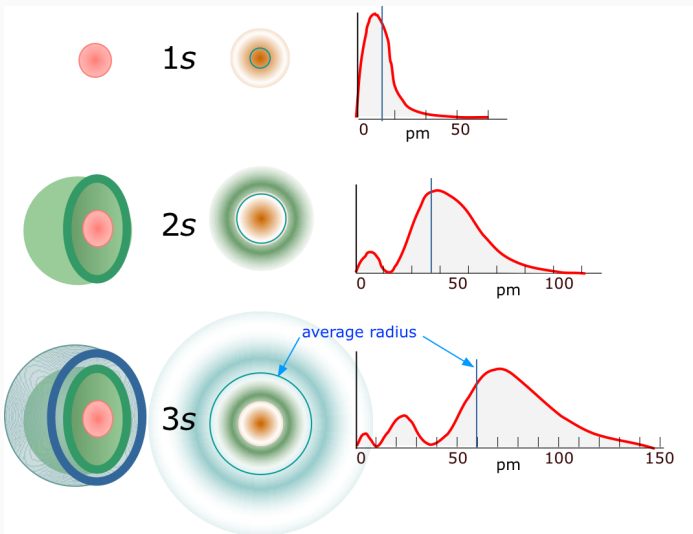
1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003
3 <b>Li</b> lithium (6,941; 6,967)	4 <b>Be</b> beryllium 9,012															10 <b>Ne</b> neon 20,18	
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31															18 <b>Ar</b> argon 39,95	
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 196,9	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium 204,3; 204,4	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 208,9	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium				
57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0			
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium			

# A periódusos rendszer (IUPAC 2012)

Lantanoidák, aktinoidák  $ns^2(n-1)d^1(n-2)f^{1-14}$

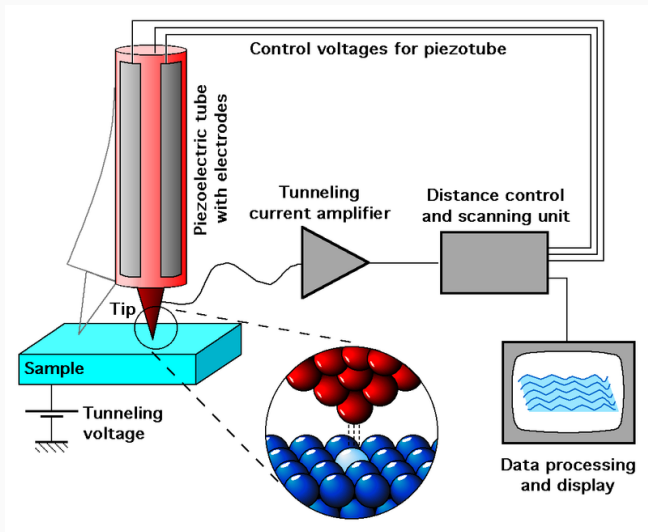
1 <b>H</b> hydrogen (1,007; 1,008)																	18 <b>He</b> helium 4,003	
3 <b>Li</b> lithium (6,941; 6,947)	4 <b>Be</b> beryllium 9,012											5 <b>B</b> boron (10,81; 10,83)	6 <b>C</b> carbon (12,01; 12,02)	7 <b>N</b> nitrogen (14,01; 14,01)	8 <b>O</b> oxygen (15,99; 16,00)	9 <b>F</b> fluorine 18,99	10 <b>Ne</b> neon 20,18	
11 <b>Na</b> sodium 22,99	12 <b>Mg</b> magnesium 24,31											13 <b>Al</b> aluminium 26,98	14 <b>Si</b> silicon (28,08; 28,09)	15 <b>P</b> phosphorus 30,97	16 <b>S</b> sulfur (32,01; 32,06)	17 <b>Cl</b> chlorine (35,44; 35,45)	18 <b>Ar</b> argon 39,95	
19 <b>K</b> potassium 39,10	20 <b>Ca</b> calcium 40,08	21 <b>Sc</b> scandium 44,96	22 <b>Ti</b> titanium 47,87	23 <b>V</b> vanadium 50,94	24 <b>Cr</b> chromium 52,00	25 <b>Mn</b> manganese 54,94	26 <b>Fe</b> iron 55,85	27 <b>Co</b> cobalt 58,93	28 <b>Ni</b> nickel 58,69	29 <b>Cu</b> copper 63,55	30 <b>Zn</b> zinc 65,38(2)	31 <b>Ga</b> gallium 69,72	32 <b>Ge</b> germanium 72,63	33 <b>As</b> arsenic 74,92	34 <b>Se</b> selenium 78,96(3)	35 <b>Br</b> bromine 79,90	36 <b>Kr</b> krypton 83,80	
37 <b>Rb</b> rubidium 85,47	38 <b>Sr</b> strontium 87,62	39 <b>Y</b> yttrium 88,91	40 <b>Zr</b> zirconium 91,22	41 <b>Nb</b> niobium 92,91	42 <b>Mo</b> molybdenum 95,94(2)	43 <b>Tc</b> technetium 98,91	44 <b>Ru</b> ruthenium 101,1	45 <b>Rh</b> rhodium 102,9	46 <b>Pd</b> palladium 106,4	47 <b>Ag</b> silver 107,9	48 <b>Cd</b> cadmium 112,4	49 <b>In</b> indium 114,8	50 <b>Sn</b> tin 118,7	51 <b>Sb</b> antimony 121,8	52 <b>Te</b> tellurium 127,6	53 <b>I</b> iodine 126,9	54 <b>Xe</b> xenon 131,3	
55 <b>Cs</b> caesium 132,9	56 <b>Ba</b> barium 137,3	57-71 lanthanoids	72 <b>Hf</b> hafnium 178,5	73 <b>Ta</b> tantalum 180,9	74 <b>W</b> tungsten 183,8	75 <b>Re</b> rhenium 186,2	76 <b>Os</b> osmium 192,2	77 <b>Ir</b> iridium 192,2	78 <b>Pt</b> platinum 195,1	79 <b>Au</b> gold 197,0	80 <b>Hg</b> mercury 200,6	81 <b>Tl</b> thallium (204,3; 204,4)	82 <b>Pb</b> lead 207,2	83 <b>Bi</b> bismuth 209,0	84 <b>Po</b> polonium	85 <b>At</b> astatine	86 <b>Rn</b> radon	
87 <b>Fr</b> francium	88 <b>Ra</b> radium	89-103 actinoids	104 <b>Rf</b> rutherfordium	105 <b>Db</b> dubnium	106 <b>Sg</b> seaborgium	107 <b>Bh</b> bohrium	108 <b>Hs</b> hassium	109 <b>Mt</b> meitnerium	110 <b>Ds</b> darmstadtium	111 <b>Rg</b> roentgenium	112 <b>Cn</b> copernicium	114 <b>Fl</b> flerovium	116 <b>Lv</b> livermorium					
57 <b>La</b> lanthanum 138,9	58 <b>Ce</b> cerium 140,1	59 <b>Pr</b> praseodymium 140,9	60 <b>Nd</b> neodymium 144,2	61 <b>Pm</b> promethium	62 <b>Sm</b> samarium 150,4	63 <b>Eu</b> europium 152,0	64 <b>Gd</b> gadolinium 157,3	65 <b>Tb</b> terbium 158,9	66 <b>Dy</b> dysprosium 162,5	67 <b>Ho</b> holmium 164,9	68 <b>Er</b> erbium 167,3	69 <b>Tm</b> thulium 168,9	70 <b>Yb</b> ytterbium 173,1	71 <b>Lu</b> lutetium 175,0				
89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232,0	91 <b>Pa</b> protactinium 231,0	92 <b>U</b> uranium 238,0	93 <b>Np</b> neptunium	94 <b>Pu</b> plutonium	95 <b>Am</b> americium	96 <b>Cm</b> curium	97 <b>Bk</b> berkelium	98 <b>Cf</b> californium	99 <b>Es</b> einsteinium	100 <b>Fm</b> fermium	101 <b>Md</b> mendelevium	102 <b>No</b> nobelium	103 <b>Lr</b> lawrencium				

# Atomsugár

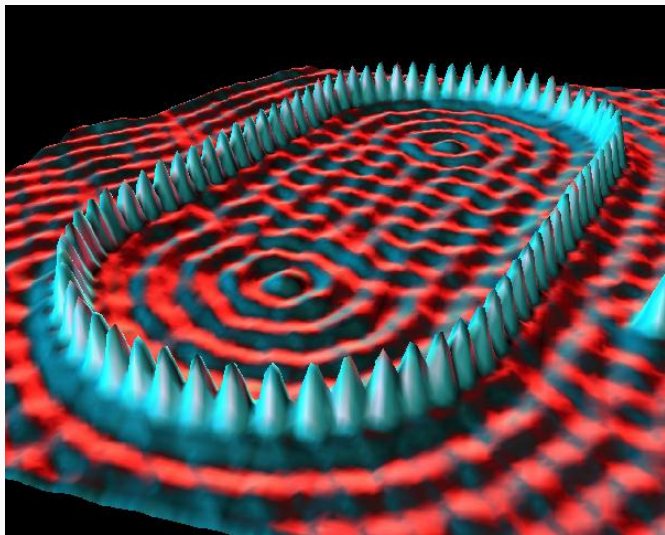




# Pásztázó alagútmikroszkóp



# Pásztázó alagútmikroszkóp



Vas atomok

réz felületen

- Kovalens sugár: a homonukleáris molekula kötéstávolságának fele.

- Kovalens sugár: a homonukleáris molekula kötéstávolságának fele.
- Ionos sugár: az ionrács rácsállandójából számítható (Pauling szerint  $O^{2-}$  140 pm)

- Kovalens sugár: a homonukleáris molekula kötéstávolságának fele.
- Ionos sugár: az ionrács rácsállandójából számítható (Pauling szerint  $O^{2-}$  140 pm)
- Fémes sugár: fémesrács rácstávolságának a fele (függ a rácstípustól).

# Atomsugár

- Kovalens sugár: a homonukleáris molekula kötéstávolságának fele.
- Ionos sugár: az ionrács rácsállandójából számítható (Pauling szerint  $O^{2-}$  140 pm)
- Fémes sugár: fémesrács rácstávolságának a fele (függ a rácstípustól).
- van der Waals sugár: az a távolság, amelyre megközelítheti egymást két azonos, de kötésben nem lévő atom gázállapotban.

# Atomsugár

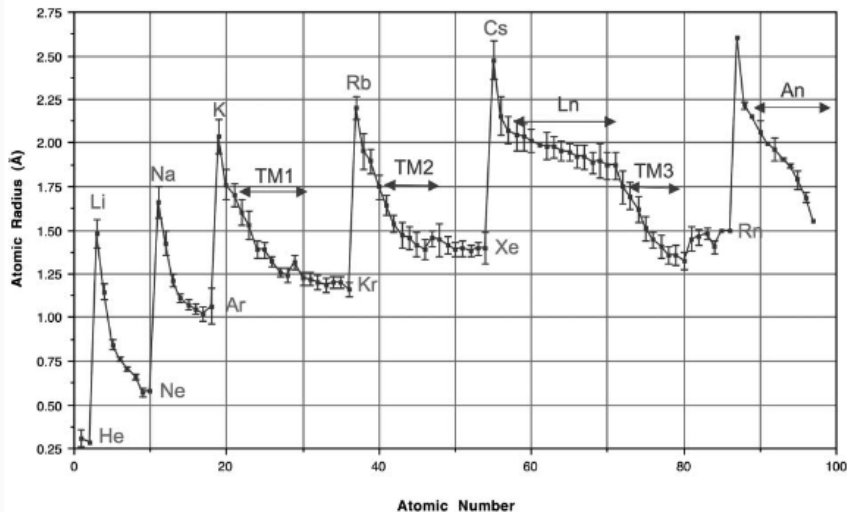
- Kovalens sugár: a homonukleáris molekula kötéstávolságának fele.
- Ionos sugár: az ionrács rácsállandójából számítható (Pauling szerint  $O^{2-}$  140 pm)
- Fémes sugár: fémesrács rácstávolságának a fele (függ a rácstípustól).
- van der Waals sugár: az a távolság, amelyre megközelítheti egymást két azonos, de kötésben nem lévő atom gázállapotban.

# Atomsugár

Elem	Kovalens sugár	van der Waals sugár	Fémes sugár
Magnézium	130 pm	173 pm	160 pm
Alummínium	118 pm	184 pm	173 pm
Szén	77 pm	170 pm	–



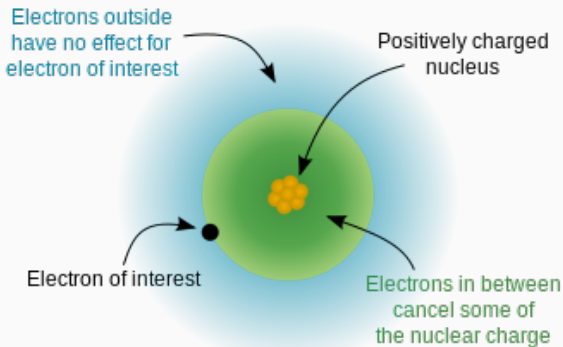
# Atomsugár



# Atomsugár

Effektív magtöltés:

$$Z_{\text{eff}} = Z - S$$



# Átomsugár

Effektív magtöltés:

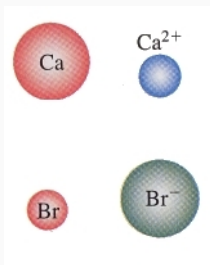
$$Z_{\text{eff}} = Z - S$$

$l$	...	$n_{i-1}$	$n_i$
0	1,0	0,85	0,3
1	1,0	0,85	0,35
2	1,0	1,0	0,35
3	1,0	1,0	0,35

$$\text{Na } 1s^2 2s^2 2p^6 3s^1 \quad Z_{\text{eff}} = 11 - (2 \times 1 + 8 \times 0,85) = 2,2$$

$$\text{Al } 1s^2 2s^2 2p^6 3s^2 3p^1 \quad Z_{\text{eff}} = 13 - (2 \times 1 + 8 \times 0,85 + 2 \times 0,3) = 3,6$$

# Ionsugár

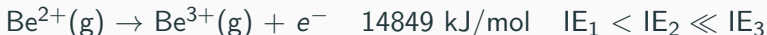


Izoelektronos sorozat ( $10e^-$ )

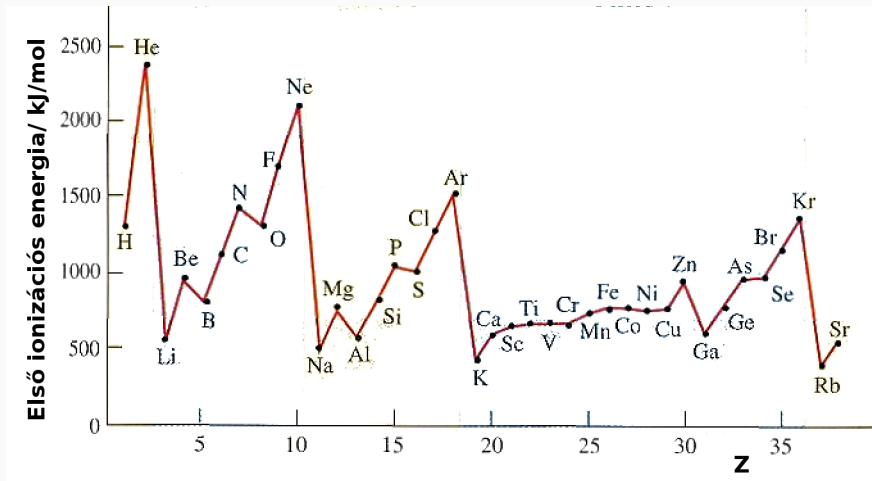
	Na <sup>+</sup>	Mg <sup>2+</sup>	Al <sup>3+</sup>
sugár (nm)	0,097	0,066	0,051

# Ionizációs energia

Az első ionizációs energia: egy gázállapotú atomból a legkönnyebben leszakítható elektron eltávolításához szükséges energia.



# Ionizációs energia



# Ionizációs energia



IUPAC Periodic Table of the Elements

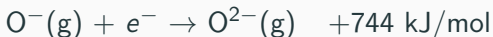
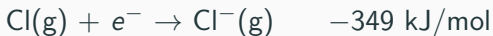
1																13										14										15										16										17										18									
1 H Hydrogen 1.007 94(7)																																																																		2 He Helium 4.002 603(2)									
3 Li Lithium 6.941(2)		4 Be Beryllium 9.012 1831(5)																		5 B Boron 10.811(7)		6 C Carbon 12.010 7(8)		7 N Nitrogen 14.006 43(8)		8 O Oxygen 15.999 03(2)		9 F Fluorine 18.998 40316(5)		10 Ne Neon 20.179 7(2)																																													
11 Na Sodium 22.989 769 28(2)		12 Mg Magnesium 24.304 0(6)																		13 Al Aluminum 26.981 538 4(6)		14 Si Silicon 28.085 5(3)		15 P Phosphorus 30.973 761 2(2)		16 S Sulfur 32.06(5)		17 Cl Chlorine 35.45(3)		18 Ar Argon 39.948(1)																																													
19 K Potassium 39.098 3(1)		20 Ca Calcium 40.078(4)		21 Sc Scandium 44.955 91(2)		22 Ti Titanium 47.867(1)		23 V Vanadium 50.941 5(5)		24 Cr Chromium 51.996 1(6)		25 Mn Manganese 54.938 04(3)		26 Fe Iron 55.845(2)		27 Co Cobalt 58.933 195(5)		28 Ni Nickel 58.693 4(4)		29 Cu Copper 63.546(3)		30 Zn Zinc 65.39(2)		31 Ga Gallium 69.723(1)		32 Ge Germanium 72.64(1)		33 As Arsenic 74.921 6(2)		34 Se Selenium 78.96(2)		35 Br Bromine 79.904(1)		36 Kr Krypton 83.799(2)																																									
37 Rb Rubidium 85.4678(3)		38 Sr Strontium 87.62(3)		39 Y Yttrium 88.905 84(2)		40 Zr Zirconium 91.224(2)		41 Nb Niobium 92.906 38(2)		42 Mo Molybdenum 95.94(3)		43 Tc Technetium [98]		44 Ru Ruthenium 101.07(2)		45 Rh Rhodium 102.905 5(5)		46 Pd Palladium 106.42(1)		47 Ag Silver 107.868 2(2)		48 Cd Cadmium 112.411(8)		49 In Indium 114.818(3)		50 Sn Tin 118.710(3)		51 Sb Antimony 121.757(1)		52 Te Tellurium 127.60(3)		53 I Iodine 126.904 47(3)		54 Xe Xenon 131.29(4)																																									
55 Cs Cesium 132.905 451 9(2)		56 Ba Barium 137.327(2)		Lanthanoids																57 La Lanthanum 138.904 7(3)		58 Ce Cerium 140.12(1)		59 Pr Praseodymium 140.907 63(3)		60 Nd Neodymium 144.24(2)		61 Pm Promethium [145]		62 Sm Samarium 150.36(2)		63 Eu Europium 151.964(1)		64 Gd Gadolinium 157.25(2)		65 Tb Terbium 158.907 3(3)		66 Dy Dysprosium 162.50(2)		67 Ho Holmium 164.930 3(3)		68 Er Erbium 167.259(2)		69 Tm Thulium 168.930 2(3)		70 Yb Ytterbium 173.054(1)		71 Lu Lutetium 174.967(1)																											
87 Fr Francium [223]		88 Ra Radium [226]		89-103 Actinoids		104 Rf Rutherfordium [261]		105 Db Dubnium [262]		106 Sg Seaborgium [263]		107 Bh Bohrium [264]		108 Hs Hassium [265]		109 Mt Meitnerium [266]		110 Ds Darmstadtium [267]		111 Rg Roentgenium [268]																																																							
89 Ac Actinium [227]		90 Th Thorium 232.037 7(4)		91 Pa Protactinium 231.036 886(2)		92 U Uranium 238.028 91(3)		93 Np Neptunium [237]		94 Pu Plutonium [244]		95 Am Americium [243]		96 Cm Curium [247]		97 Bk Berkelium [247]		98 Cf Californium [251]		99 Es Einsteinium [252]		100 Fm Fermium [257]		101 Md Mendelevium [258]		102 No Nobelium [259]		103 Lr Lawrencium [260]																																															



Notes  
 - "darmstadtium" and "meitnerium" are commonly used alternative spellings for "darmstadtium" and "meitnerium".  
 - IUPAC 2015 standard atomic weights (mean relative atomic masses) are listed with uncertainties in the last figure in parentheses (M. E. Wieser, Pure Appl. Chem. 78, 2011 (2006)).  
 - These values correspond to current best knowledge of the isotopic natural isotopic composition. For elements that have no stable or long-lived isotopes, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.  
 - Elements with atomic numbers 112 and above have been reported but not fully characterized.

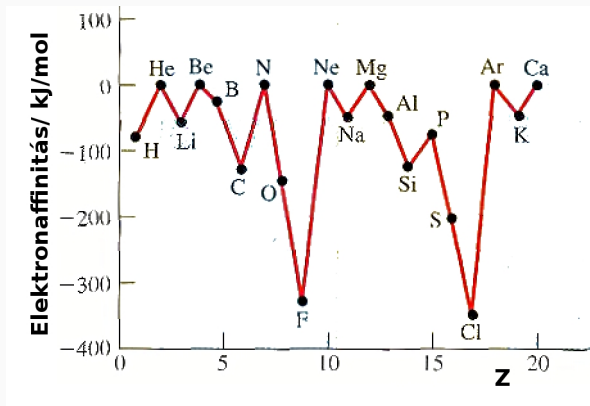
Copyright © 2007 IUPAC, the International Union of Pure and Applied Chemistry. For updates to this table, see [http://www.iupac.org/pure/periodic\\_table](http://www.iupac.org/pure/periodic_table). This version is dated 12 June 2007.

Egy gázállapotú atomból egyszeresen negatív töltésű ion keletkezését kísérő energia változás.





# Elektronaffinitás



# Elektronaffinitás



IUPAC Periodic Table of the Elements

IUPAC Periodic Table of the Elements																																			
										13	14	15	16	17																					
1	2												3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18							
H 1.007 84(7)	Li 6.941(2)	Be 9.012 18(3)											B 10.811(7)	C 12.010 7(8)	N 14.006 4(1)	O 15.999 03(2)	F 18.998 4032(3)	Ne 19.992 479(2)											Ar 39.948 1(6)	Kr 83.798(4)	Xe 131.29(8)	Rn 222(2)			
3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18					
Sc 44.955 91(2)		Ti 47.867(1)		V 50.941 5(1)		Cr 51.996 1(6)		Mn 54.938 04(4)		Fe 55.845(2)		Co 58.933 19(5)		Ni 58.693 4(4)		Cu 63.546(3)		Zn 65.38(4)		Ga 69.723(1)		Ge 72.64(1)		As 74.921 6(2)		Se 78.96(4)		Br 79.904(1)		Kr 83.798(4)					
Rb 85.468(4)		Sr 87.62(1)		Y 88.905 8(2)		Zr 91.224(2)		Nb 92.906 38(2)		Mo 95.94(1)		Tc 98.906 2(1)		Ru 101.07(2)		Rh 102.905 5(2)		Pd 106.905 09(2)		Ag 107.868 2(2)		Cd 112.411(8)		In 114.818(1)		Sn 118.710(3)		Sb 121.757(1)		Te 127.60(3)		I 126.905 4(5)		Xe 131.29(8)	
Cs 132.905 451(3)		Ba 137.327(1)		La 138.904 71(3)		Ce 140.12(1)		Pr 140.907 65(2)		Nd 144.242(3)		Pm 144.912 8(2)		Sm 150.35(2)		Eu 151.964(1)		Gd 157.25(3)		Tb 158.925 1(5)		Dy 162.500 1(5)		Ho 164.930 32(2)		Er 167.259(3)		Tm 168.930 4(2)		Yb 173.054(7)		Lu 174.967(1)			
Fr 223(2)		Ra 226(2)		Ac 227(2)		Th 232.037 7(4)		Pa 231.036 88(2)		U 238.028 91(3)		Np 237.048 1(3)		Pu 244(1)		Am 243(1)		Cm 247(1)		Bk 247(1)		Cf 251(1)		Es 252(1)		Fm 257(1)		Md 258(1)		No 259(1)		Lr 262(1)			

Notes

<sup>1</sup> "Aluminium" and "caesium" are commonly used obsolescent spellings for "aluminum" and "cesium".

<sup>2</sup> IUPAC 2019 identified atomic weights (mean relative atomic masses) are listed with uncertainties in the last figure in parentheses (M. E. Wieser, Pure Appl. Chem. 79, 2017 (2019)).

<sup>3</sup> These values correspond to current best knowledge of the elements in natural terrestrial sources. For elements that have no stable or long-lived isotopes, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.

<sup>4</sup> Elements with atomic numbers 112 and above have not been reported but not fully characterized.

Copyright © 2017 IUPAC, the International Union of Pure and Applied Chemistry. For updates to this table, see [http://www.iupac.org/reports/periodic\\_table](http://www.iupac.org/reports/periodic_table). This version is dated 22 June 2017.

A kötésben lévő atom elektronvonzó képessége.

Pauling definíciója

energy a maximum, we see that *the energy of an actual bond between unlike atoms is greater than (or equal to) the energy of a normal covalent bond between these atoms.* This additional bond energy is due to the *additional ionic character of the bond*; that is, it is the *additional ionic resonance energy* that the bond has as compared with a bond between like atoms. In referring to these quantities later we shall omit the

(L. Pauling: The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry)

$$\Delta = E_{AB} - \frac{E_{AA} + E_{BB}}{2}$$

# Elektronegativitás

TABLE 3-2.—BOND ENERGIES FOR HYDROGEN HALOGENIDE AND HALOGEN HALOGENIDE MOLECULES (KCAL/MOLE)

	H—H	F—F	Cl—Cl	Br—Br	I—I
Bond energy	104.2	36.6	58.0	46.1	36.1
		H—F	H—Cl	H—Br	H—I
Bond energy		134.6	103.2	87.5	71.4
$\frac{1}{2}\{D(\text{H—H}) + D(\text{X—X})\}$		70.4	81.1	75.2	70.2
$\Delta$		64.2	22.1	12.3	1.2
		Cl—F	Br—Cl	I—Cl	I—Br
Bond energy		60.6	52.3	50.3	42.5
$\frac{1}{2}\{D(\text{X—X}) + D(\text{X'—X'})\}$		47.3	52.1	47.1	41.1
$\Delta$		13.3	0.2	3.2	1.4

(L. Pauling: The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry)

# Elektronegativitás

Geometriai középérték:  $\Delta' = E_{AB} - \sqrt{E_{AA} + E_{BB}}$

$$EN_A - EN_B \sim \sqrt{\Delta'}$$

TABLE 3-6.—EXTRA IONIC ENERGY OF BONDS AND ELECTRONEGATIVITY DIFFERENCES OF THE BONDED ATOMS

Bond	$\Delta'$	$0.18\sqrt{\Delta'}$	$x_A - x_B$	Bond	$\Delta'$	$0.18\sqrt{\Delta'}$	$x_A - x_B$
C—H	5.8	0.4	0.4	Si—S	7.8	0.6	0.7
Si—H	4.0	.4	.3	Si—F	90.0	1.7	2.2
N—H	30.1	1.0	.9	Si—Cl	36.2	1.1	1.2
P—H	3.3	0.3	.0	Si—Br	25.0	0.9	1.0
As—H	0.8	.2	.1	Si—I	11.8	.6	0.7
O—H	41.8	1.2	1.4	Ge—Cl	50.8	1.3	1.2
S—H	8.3	0.5	0.4	N—F	27.0	0.9	1.0
Se—H	-1.6	—	.3	N—Cl	0.5	.1	0.0
Te—H	-1.9	—	.0	P—Cl	24.5	.9	.9
H—F	72.9	1.5	1.9	P—Br	16.7	.7	.7
H—Cl	25.4	0.9	0.9	P—I	8.3	.5	.4
H—Br	18.2	0.8	.7	As—F	77.0	1.6	2.0
H—I	10.1	.6	.4	As—Cl	25.8	0.9	1.0
C—Si	10.0	.6	.7	As—Br	18.0	.8	0.8
C—N	13.2	.7	.5	As—I	7.5	.5	.5
C—O	31.5	1.0	1.0	O—F	9.3	.5	.5
C—S	-2.4	—	0.0	O—Cl	4.6	.4	.5
C—F	50.2	1.3	1.5	S—Cl	5.3	.4	.5
C—Cl	9.1	0.5	0.5	S—Br	2.2	.3	.3
C—Br	4.0	.4	.3	Cl—F	14.5	.7	1.0

A kötésben lévő atom elektronvonzó képessége.

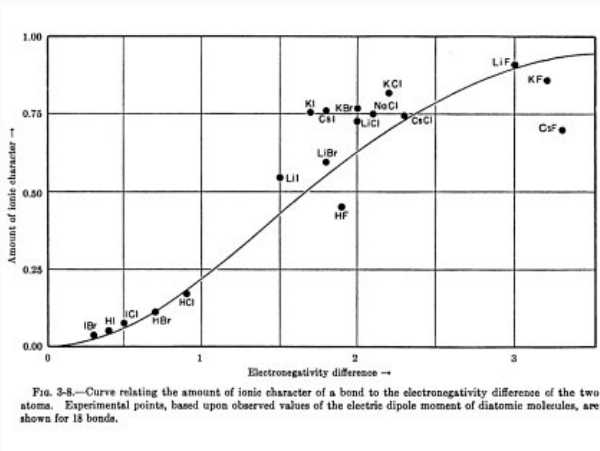
Pauling definíciója

$$\Delta' = E_{AB} - \sqrt{E_{AA} + E_{BB}}$$

$$EN_A - EN_B = 0.18\sqrt{\Delta'}$$

$$EN_F = 4.0$$

# Elektronegativitás



(L. Pauling: The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry)

# Elektronegativitás

Mulliken definíciója

$$EN = \frac{IE + EA}{130}$$

TABLE 3-9.—COMPARISON OF ELECTRONEGATIVITY WITH AVERAGE OF IONIZATION ENERGY AND ELECTRON AFFINITY\*

	Ionization energy	Electron affinity	Sum/125	$x$
F	403.3	83.5	3.90	4.0
Cl	300.3	87.3	3.10	3.0
Br	274.6	82.0	2.86	2.8
I	242.2	75.7	2.54	2.5
H	315.0	17.8	2.66	2.1
Li	125.8	0	1.01	1.0
Na	120.0	0	.96	0.9
K	101.6	0	.81	.8
Rb	97.8	0	.78	.8
Cs	91.3	0	.73	.7

\* All values are for  $-\Delta H^\circ$  at 25°C.

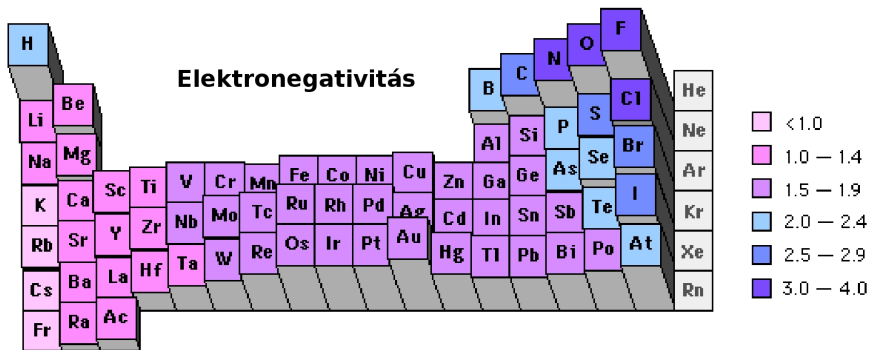
(L. Pauling: The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry)



Alfred és Rochow definíciója

$$EN = 0,359 \frac{Z_{eff}}{r^2} + 0,744$$

# Elektronegativitás



Relativisztikus effektusok:

$$E = \frac{p^2}{2m} \text{ (klasszikus)}$$

$$E = \sqrt{p^2 c^2 + m^2 c^4} \text{ (relativisztikus)}$$

pl. a pályák összehúzódása, stabilizálódása

- Hg ( $T_{op} = -39^\circ\text{C}$ ) Cd ( $T_{op} = 321^\circ\text{C}$ )  
a higanyt 6s pályáinak összehúzódása inerté és kevésbé polarizálhatóvá teszi
- Au sárga, Ag fémes színű  
az arany 6s pályáinak összehúzódása növeli a 6s és 5d pályák közötti energiakülönbséget

- A periódusos rendszer (Mendelejev, Moseley)
- Periodikus tulajdonságok:
  - Atomsugár  $\downarrow^{\leftarrow}$
  - Ionizációs energia  $\uparrow^{\rightarrow}$
  - Elektronaffinitás  $\downarrow^{\leftarrow}$
  - Elektronegativitás  $\uparrow^{\rightarrow}$
  - $EN_A - EN_B = 0.102\sqrt{\Delta}$
  - kémiai tulajdonságok