

The Periodic Table

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Vocabulary

electron arrangement **alkali metals**
(electron configuration) **alkaline-earth metals**
shell **transition metals**
outer shell **halchogens**
valence electrons **halogens**
energy level **rare-earth elements**
orbital
charge **trend**
electronegativity
electron affinity
ionization potential

Chemical elements

Non-metals

H – hydrogen

F - fluorine

O – oxygen

Cl - chlorine

N – nitrogen

Br - bromine

B – boron

I - iodine

Si –silicon

P – phosphorus

He -helium

S – sulfur, sulphur

Chemical elements

Metals

sodium – Na

zinc – Zn

potassium – K

tungsten – W

magnesium - Mg

manganese – Mn

iron – Fe

lead – Pb

copper – Cu

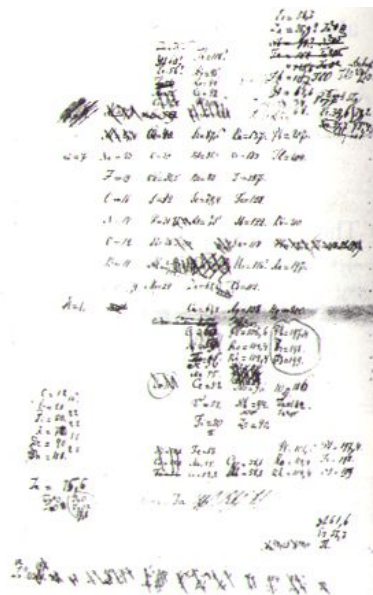
tin – Sn

silver – Ag

mercury - Hg

The Periodic Table of Chemical Elements

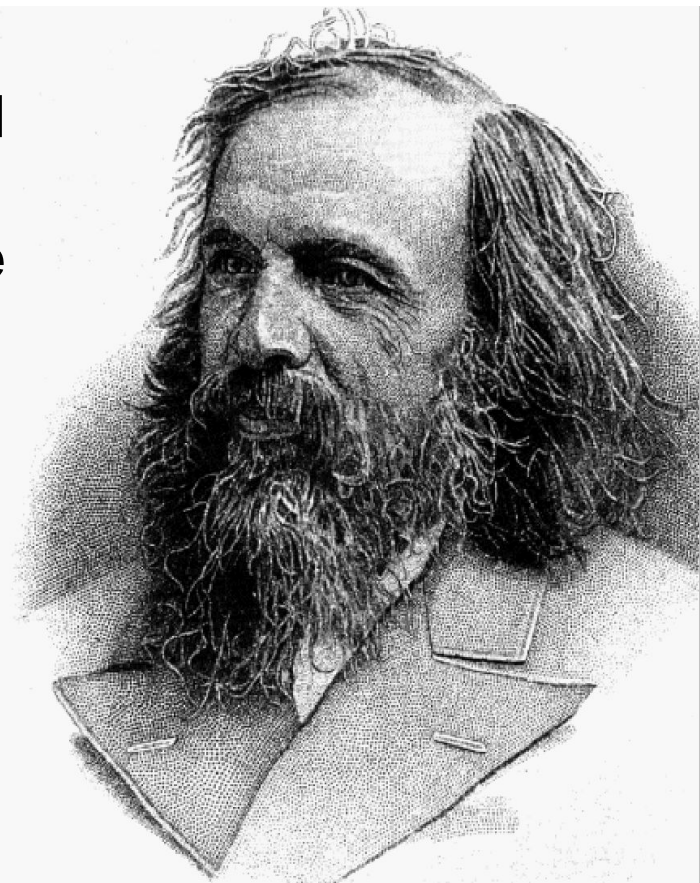
- What is the Periodic table ?
- What information is obtained from the table ?
- How can elemental properties be predicted by means of the PT ?



Dmitri Mendeleev (1869)

D.I. Mendeleev grouped elements according to their atomic mass, and as he did, he found that the families had similar chemical properties. Blank spaces were left open to add the new elements he predicted would occur.

Row	Group I — R ₂ O	Group II — RO	Group III — R ₂ O ₃	Group IV RH ₄ RO ₂	Group V RH ₃ R ₂ O ₅	Group VI RH ₂ RO ₃	Group VII RH R ₂ O ₇	Group VIII — RO ₄
1	H = 1							
2	Li = 7	Be = 9.4	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27.3	Si = 28	P = 31	S = 32	Cl = 35.5	
4	K = 39	Ca = 40	— = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56, Co = 59, Ni = 59, Cu = 63
5	(Cu = 63)	Zn = 65	— = 68	— = 72	As = 75	Se = 78	Br = 80	
6	Rb = 85	Sr = 87	?Yt = 88	Zr = 90	Nb = 94	Mo = 96	— = 100	Ru = 104, Rh = 104, Pd = 106, Ag = 108
7	(Ag = 108)	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	I = 127	
8	Cs = 133	Ba = 137	?Di = 138	?Ce = 140				
9								
10			?Er = 178	?La = 180	Ta = 182	W = 184		Os = 195, Ir = 197, Pt = 198, Au = 199
11	(Au = 199)	Hg = 200	Tl = 204	Pb = 207	Bi = 208			
12				Th = 231		U = 240		



Dmitri Mendeleev.

The Periodic Table

Henri Moseley (England, 1887-1915) established that each element has a unique atomic number, which is how the current Periodic table is organized.

Mendeleev:

"The properties of elements, as well as its compounds are periodic function of their **atomic weight**."

Modern formulation:

"The properties of chemical elements, as well as the forms and properties of the compounds of the elements are periodic function of the **nuclear charge of atoms** of the chemical elements".

Periodic changes of chemical properties of elements can be explained by the correct **repetition of electronic configuration of external energy level** (valence electrons) of their atoms with increasing charge of nucleus.

The latest version

The periodic table is shown with columns numbered 1 through 18. The d-block is labeled above the transition metals (columns 3-10), and the f-block is labeled to the left of the lanthanide and actinide series. The four new elements are highlighted in yellow: Nh (113), Mc (115), Ts (117), and Og (118).

1																	18	
1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg	d-block										Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og
f-block			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb		
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No		

The International Union of Pure and Applied Chemistry has announced the names of four elements in the Periodic table that were discovered in January 2016. **Moscovium (Mc), nihonium (Nh), tennessine (Ts) and oganesson (Og)** complete the seventh row of the table. The elements — with atomic numbers 113, 115, 117 and 118 — were discovered in a joint effort by American and Russian scientists.

Periodic Table: The three broad Classes

Main, Transition, Rare Earth

Main (Representative), Transition metals, lanthanides and actinides (rare earth)

Periodic Table of the Elements

Representative (main group) elements		Transition metals										Representative (main group) elements							
IA												IIIA	IVA	VA	VIA	VIIA	VIIIA		
1	H 1.0079																He 4.003		
2	Li 6.941	Be 9.012											B 10.811	C 12.011	N 14.007	O 15.999	F 18.998	Ne 20.180	
3	Na 22.990	Mg 24.305											Al 26.982	Si 28.086	P 30.974	S 32.066	Cl 35.453	Ar 39.948	
4	K 39.098	Ca 40.078	Sc 44.956	Ti 47.88	V 50.942	Cr 51.996	Mn 54.938	Fe 55.845	Co 58.933	Ni 58.69	Cu 63.546	Zn 65.39	Ga 69.723	Ge 72.61	As 74.922	Se 78.96	Br 79.904	Kr 83.8	
5	Rb 85.468	Sr 87.62	Y 88.906	Zr 91.224	Nb 92.906	Mo 95.94	Tc 98	Ru 101.07	Rh 102.906	Pd 106.42	Ag 107.868	Cd 112.411	In 114.82	Sn 118.71	Sb 121.76	Te 127.60	I 126.905	Xe 131.29	
6	Cs 132.905	Ba 137.327	La 138.906	Hf 178.49	Ta 180.948	W 183.84	Re 186.207	Os 190.23	Ir 192.22	Pt 195.08	Au 196.967	Hg 200.59	Tl 204.383	Pb 207.2	Bi 208.980	Po 209	At 210	Rn 222	
7	Fr 223	Ra 226.025	Ac 227.028	Rf 261	Db 262	Sg 263	Bh 262	Hs 265	Mt 266	Uun 269	Uuu 272	Uub 277		114		116		118	
			Rare earth elements																
Lanthanides			Ce 140.115	Pr 140.908	Nd 144.24	Pm 145	Sm 150.36	Eu 151.964	Gd 157.25	Tb 158.925	Dy 162.5	Ho 164.93	Er 167.26	Tm 168.934	Yb 173.04	Lu 174.967			
Actinides			Th 232.038	Pa 231.036	U 238.029	Np 237.048	Pu 244	Am 243	Cm 247	Bk 247	Cf 251	Es 252	Fm 257	Md 258	No 259	Lr 262			

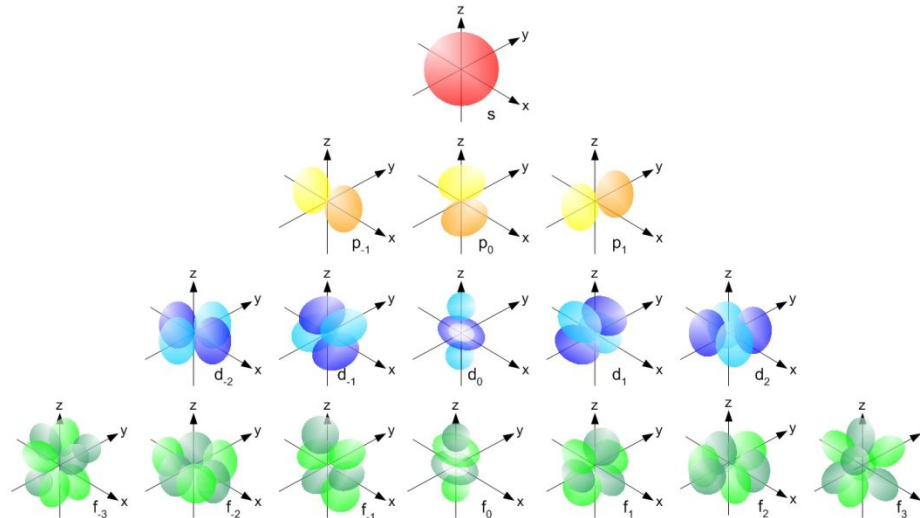
The Periodic Table

Electron Configurations in the Periodic Table

1 H 1s																	2 He 1s
3 Li 2s	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne 2p
11 Na 3s	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar 3p
19 K 4s	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn 3d	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr 4p
37 Rb 5s	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd 4d	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe 5p
55 Cs 6s	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg 5d	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn 6p
87 Fr 7s	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112 6d	113	114				
		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu 4f		
		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr 5f		

Orbitals

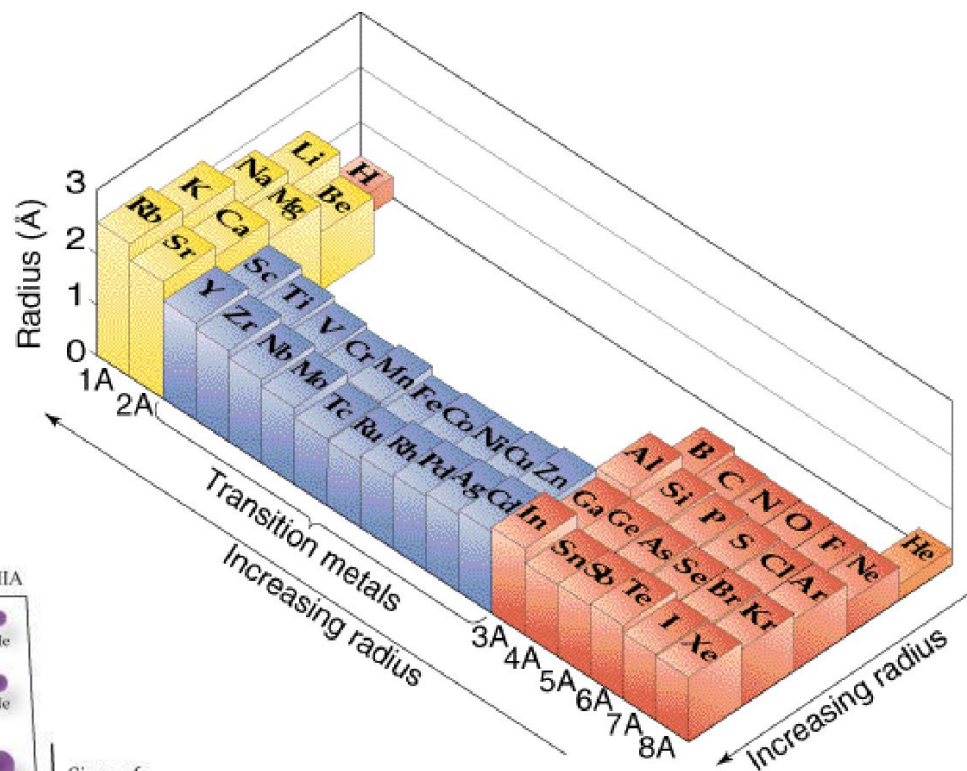
- ❖ An atom is composed of a nucleus containing neutrons and protons with electrons dispersed throughout the remaining space. **Electronic orbitals** are regions within the atom in which electrons have the highest probability of being found.
- ❖ Each orbital has its own specific energy level and properties. Because each orbital is different, they are assigned specific **quantum numbers**: 1s, 2s, 2p 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p. The numbers, (n=1,2,3, etc.) are called **principal quantum numbers** and can only be positive numbers. The letters (s,p,d,f) represent the *orbital angular momentum quantum number*.



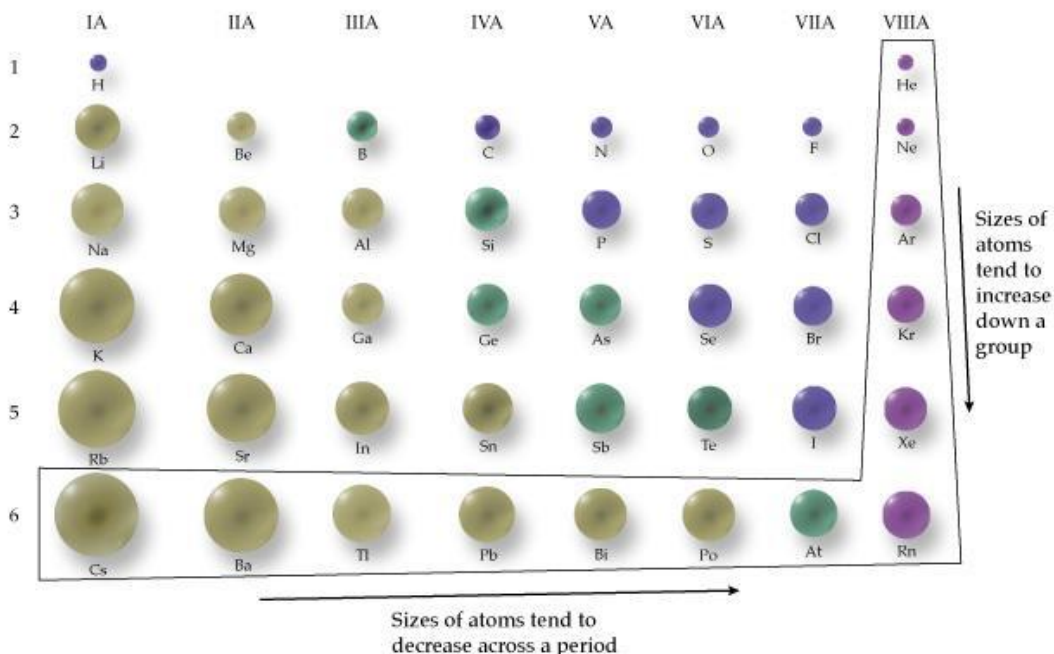
Trend in Atomic Radius

Atomic Radius:

The size of an atomic species is determined by the boundaries of the valence e- layer. Largest atomic species are those found in the SW corner since these atoms have the largest n , but the smallest Z_{eff} .



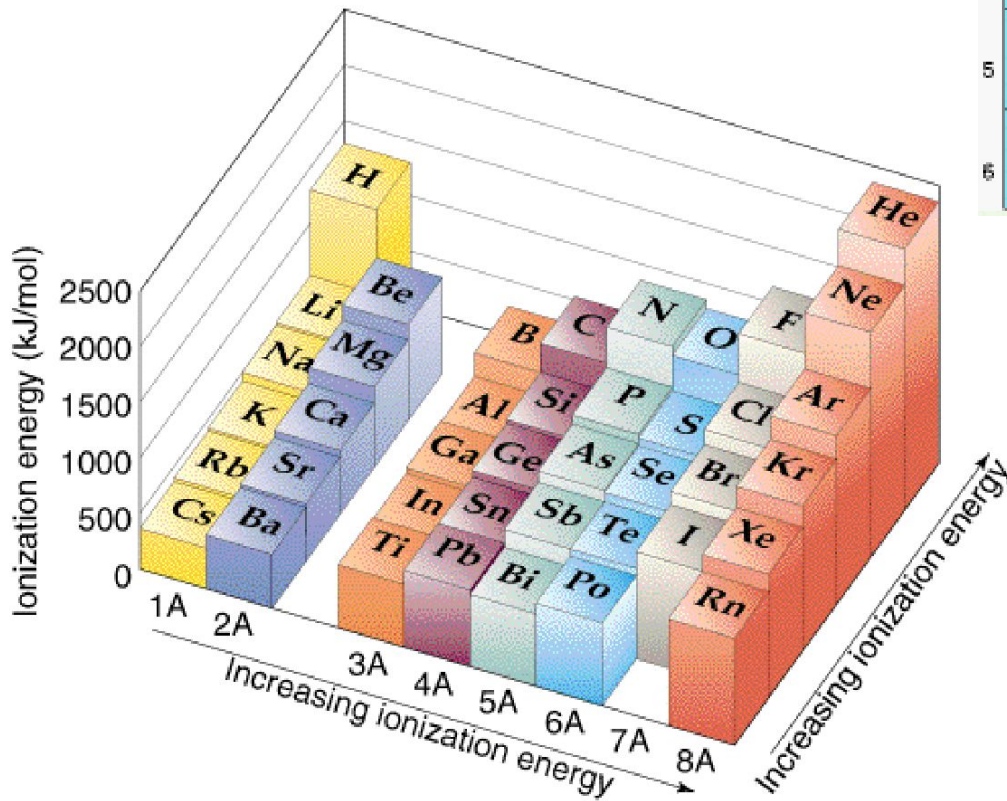
Relative Atomic Sizes of the Representative Elements



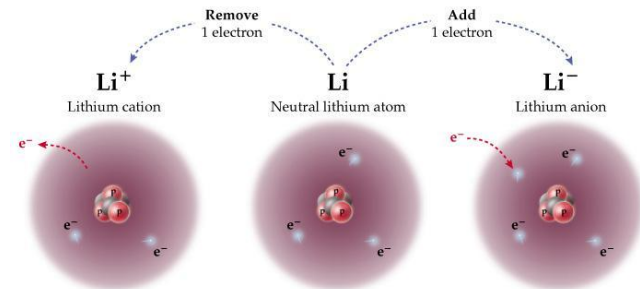
Trend in Ionization Potential

Ionization potential:

The energy required to remove the valence electron from an atomic specie. Largest toward NE corner of PT since these atoms hold on to their valence e- the tightest.



	IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	H 1312							He 2372
2	Li 520	Be 899	B 801	C 1086	N 1402	O 1314	F 1681	Ne 2081
3	Na 496	Mg 738	Al 578	Si 786	P 1012	S 1000	Cl 1251	Ar 1521
4	K 419	Ca 590	Ga 579	Ge 762	As 947	Se 941	Br 1140	Kr 1351
5	Rb 403	Sr 549	In 558	Sn 709	Sb 834	Te 869	I 1008	Xe 1170
6	Cs 376	Ba 503	Tl 589	Pb 716	Bi 703	Po 812	At 926	Rn 1037



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Trend in Electron Affinity

Electron Affinity:

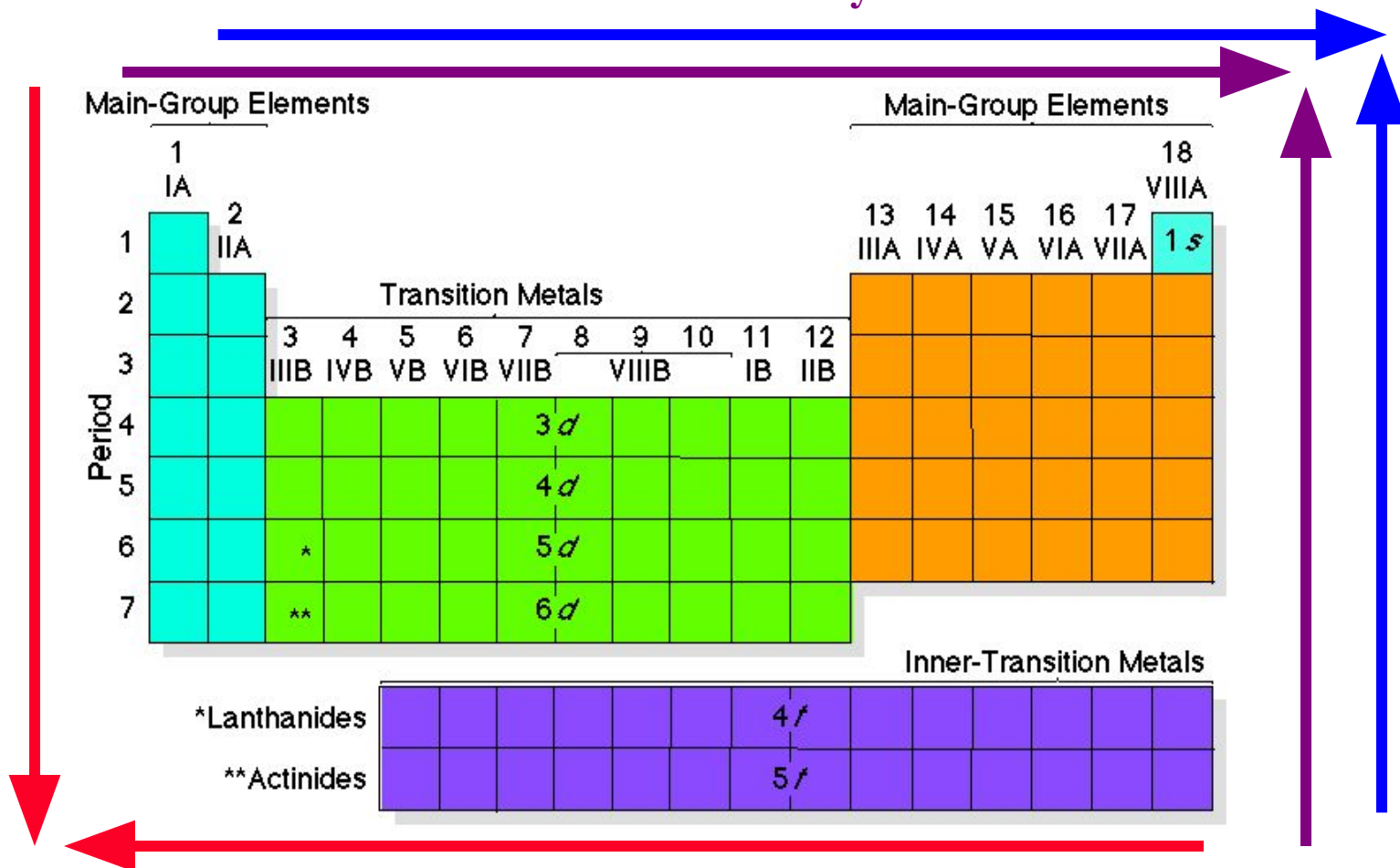
The energy release when an electron is added to an atom. Most favorable toward NE corner of PT since these atoms have a great affinity for e⁻.

H -73							He >0
Li -60	Be >0	B -27	C -122	N >0	O -141	F -328	Ne >0
Na -53	Mg >0	Al -43	Si -134	P -72	S -200	Cl -349	Ar >0
K -48	Ca -4	Ga -30	Ge -119	As -78	Se -195	Br -325	Kr >0
Rb -47	Sr -11	In -30	Sn -107	Sb -103	Te -190	I -295	Xe >0
1A	2A	3A	4A	5A	6A	7A	8A

Summary of Trends

Ionization Energy: Largest toward NE of PT

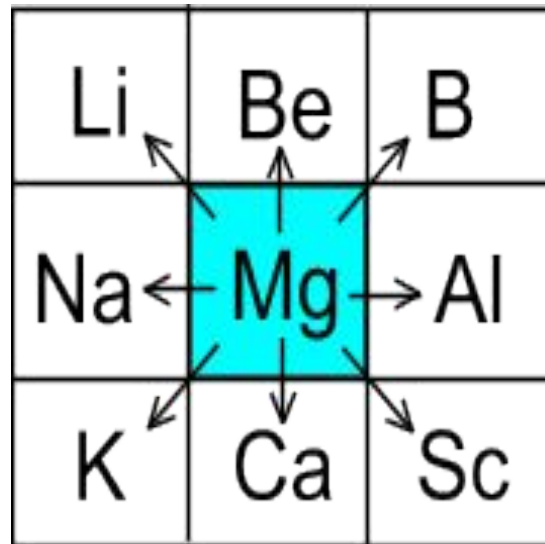
Electron Affinity: Most favorable NE of PT



Atomic Radius: Largest toward SW corner of PT

Summary of Trends

On the position of element in the Periodic system possible to forecast its basic properties, as average of all its neighbors:



Summary

Periodic Table: Map of the Building blocks of matter

Types: Metals and Nonmetals

Families: Elements in the same column have similar chemical properties because of similar electronic configuration of the outer shell.

Alkali, Alkaline, chalcogens, halogens, noble gases

Periods: Elements in the same row have valence electrons in the same shell.

Groups: Elements in the same group have the same number of valence electrons .

Hydrogen

- The hydrogen square sits atop Family Al, but it is not a member of that family. Hydrogen is in a class of its own.
- It's a gas at room temperature.
- It has one proton and one electron in its one and only energy level (s-orbital).
- Hydrogen only needs 2 electrons to fill up its valence shell.

Periodic Table of the Elements

The diagram shows a simplified periodic table of elements represented by a grid of squares. The top-left square is highlighted in orange, representing Hydrogen. The rest of the grid is gray. The grid is arranged in a standard periodic table layout with 7 rows and 18 columns, with the noble gases (Group 18) forming a separate column on the right side. The text 'Periodic Table of the Elements' is written above the grid.

Alkali metals

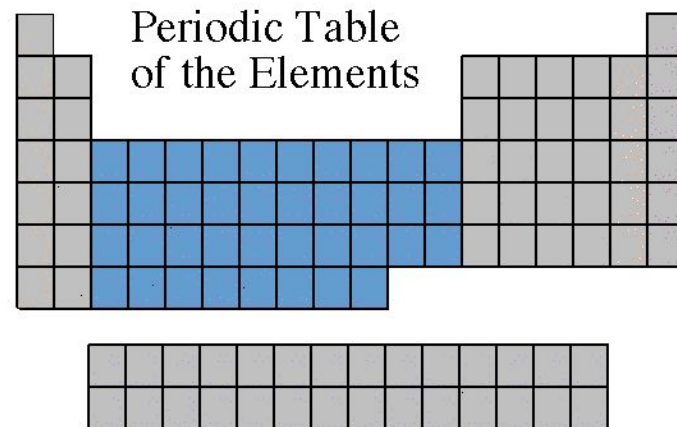
- The alkali family is found in the first column of the Periodic table.
- Atoms of the alkali metals have a single electron in their outermost level, in other words, 1 valence electron.
- They are shiny, have the consistency of clay, and are easily cut with a knife.
- They are the most reactive metals.
- They react violently with water.
- Alkali metals are never found as free elements in nature. They are always bonded with another element.

Periodic Table of the Elements

The diagram shows a simplified periodic table with a grid of cells. The first column on the left is highlighted in yellow, representing the alkali metals. The rest of the table is grey. The table is arranged in four rows: the first row has 2 cells, the second row has 2 cells, the third row has 18 cells, and the fourth row has 18 cells. The first column is highlighted in yellow in all four rows.

Transition Metals

- Transition Elements include those elements in the B families.
- Transition elements have **1 or 2 valence electrons**, which they lose when they form bonds with other atoms. Some transition elements can lose **electrons in their next-to-outermost level**.
 - Low ionization energies
 - Positive oxidation states, multiple oxidation states, since there is a low energy gap between them
 - Very hard
 - Exhibit metallic luster
 - High melting and boiling points
 - High electrical conductivity
 - High thermal conductivity
 - Malleable
 - Form colored compounds, due to d-d electronic transitions
 - Typically exhibit high catalytic activity



Boron Family

- The Boron Family is named after the first element in the family.
- Atoms in this family have **3 valence electrons**.
- This family includes a **metalloid** (boron), and the rest are **metals**.
- This family includes the most abundant metal in the Earth's crust (aluminum).

Periodic Table of the Elements

The diagram shows a simplified periodic table with a grid of cells. The cells are shaded gray. A vertical column of three cells is highlighted in red, representing the Boron Family. The text 'Periodic Table of the Elements' is written above the grid.

Carbon Family

- Atoms of this family have **4 valence electrons**.
- This family includes **non-metals (carbon and silicon) and metals**.
- The element carbon is called the “basis of life.” There is an entire branch of chemistry devoted to carbon compounds called organic chemistry.

Periodic Table of the Elements

The diagram shows a simplified periodic table with a vertical column of four cells highlighted in yellow. This column represents the carbon family, which includes elements from groups 14 and 32. The highlighted cells are located in the second, third, fourth, and fifth rows of the main body of the table. Below the main table, there is a separate horizontal row of 10 cells, representing the lanthanide and actinide series.

Oxygen Family

- Atoms of this family have **6 valence electrons**.
- Most elements in this family share electrons when forming compounds.
- Oxygen is the most abundant element in the earth's crust. It is extremely active and combines with almost all elements.

Periodic Table of the Elements

The diagram shows a simplified periodic table with a grid of cells. The cells are arranged in rows and columns. A vertical column of six cells is highlighted in blue, representing the Oxygen family (Group 16). The text 'Periodic Table of the Elements' is written above the grid.

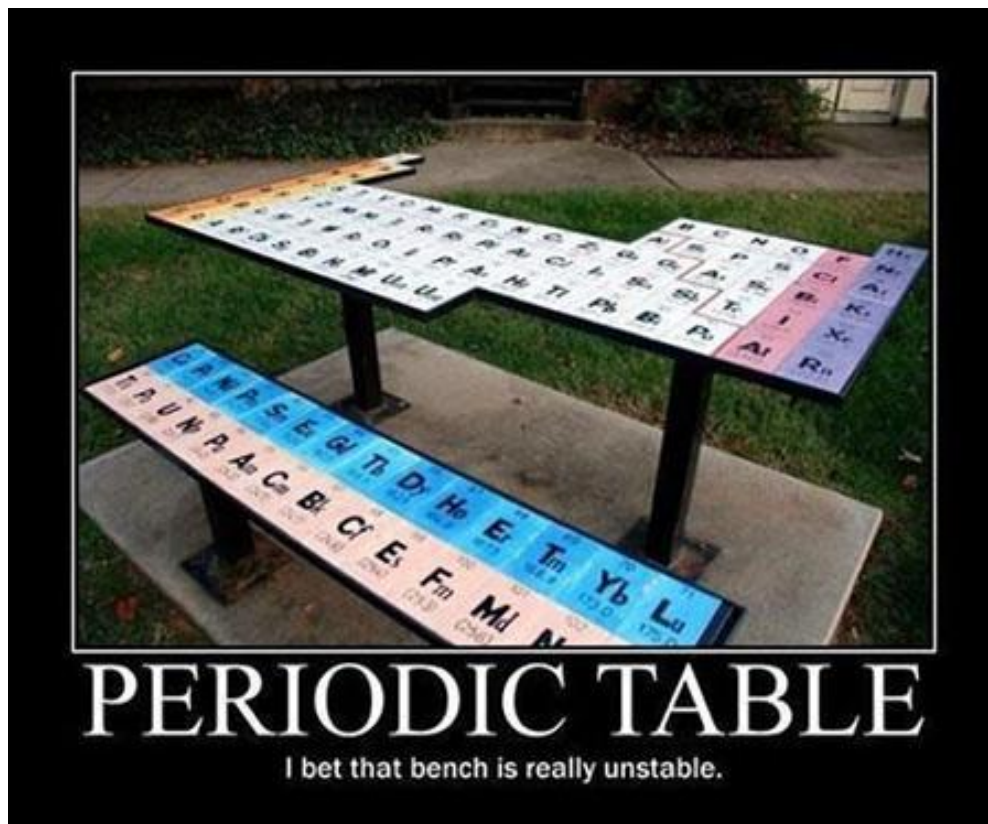
Rare Earth Elements

- **The thirty rare earth elements are composed of the lanthanide and actinide series.**
- **One element of the lanthanide series and most of the elements in the actinide series are called trans-uranium, which means synthetic or man-made.**

Periodic Table
of the Elements

The image shows a schematic periodic table of elements. The main body of the table is a grid of 18 columns and 7 rows, with the first and last columns being shorter. Below this main grid, there are two horizontal rows of 14 cells each, representing the lanthanide and actinide series. These two rows are highlighted in light blue, while the rest of the periodic table is shown in light gray.

Thanks for your attention!



<http://www.periodictable.com/>