



Periodic table of elements

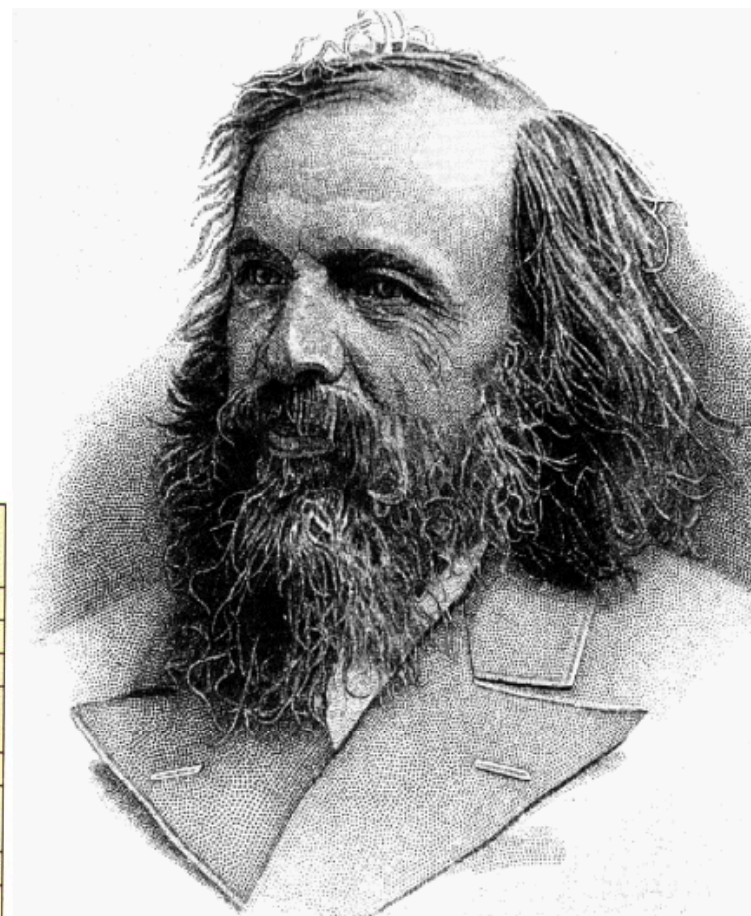
Periodic Table

- The periodic table organizes the elements in a particular way. A great deal of information about an element can be gathered from its position in the period table.
- For example, you can predict with reasonably good accuracy the physical and chemical properties of the element. You can also predict what other elements a particular element will react with chemically.
- Understanding the organization and plan of the periodic table will help you obtain basic information about each of the 118 known elements.

Dmitri Mendeleev (1869)

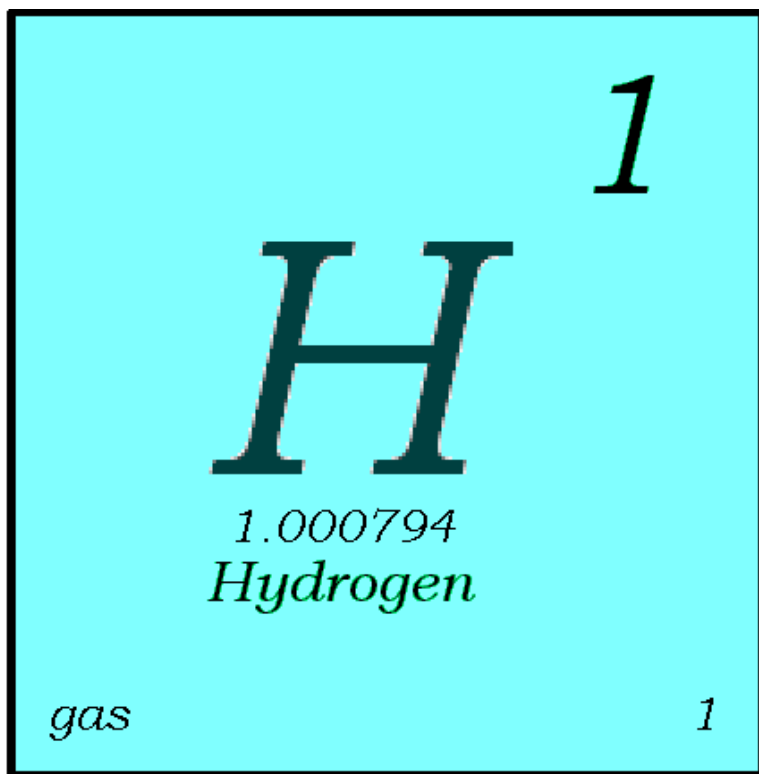
In 1869 Mendeleev and Lothar Meyer (Germany) published nearly identical classification schemes for elements known to date. The periodic table is based on the similarity of properties and reactivities exhibited by certain elements. Later, Henri Moseley (England, 1887-1915) established that each element has a unique atomic number, which is how the current periodic table is organized.

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.

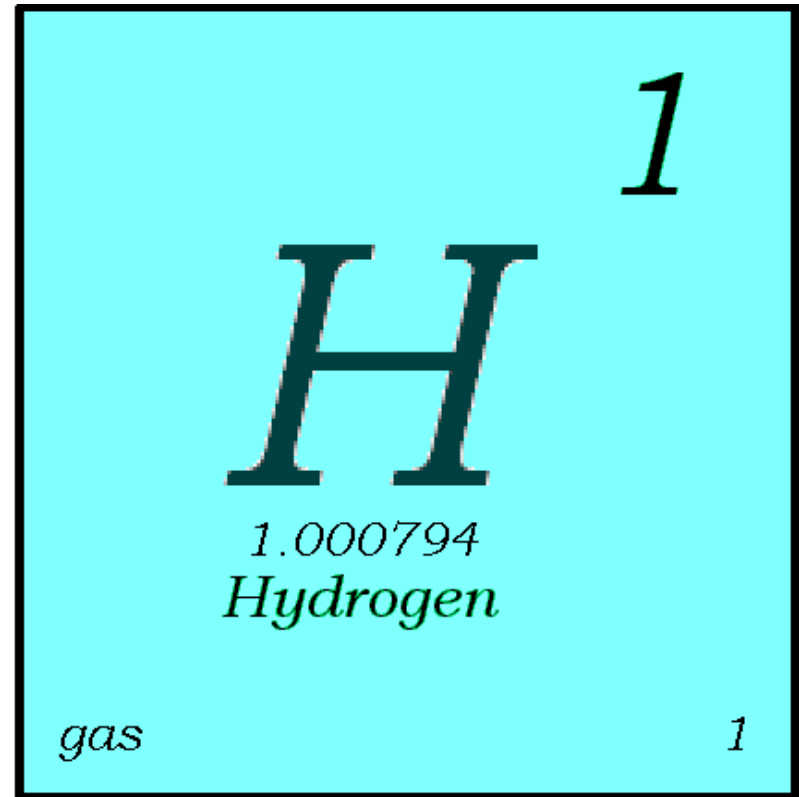
Key to the Periodic Table



- Elements are organized on the table according to their atomic number, usually found near the top of the square.
 - The atomic number refers to how many protons an atom of that element has.
 - For instance, hydrogen has 1 proton, so its atomic number is 1.
 - The atomic number is unique to that element. No two elements have the same atomic number.

What's in a square?

- Different periodic tables can include various bits of information, but usually:
 - atomic number
 - symbol
 - atomic mass
 - number of valence electrons
 - state of matter at room temperature.



Periodic Table Expanded View

- The way the periodic table usually seen is a compressed view, placing the Lanthanides and actinides at the bottom of the table.
- The Periodic Table can be arranged by subshells. The s-block is Group IA and IIA, the p-block is Group IIIA - VIIIA. The d-block is the transition metals, and the f-block are the Lanthanides and Actinide metals

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

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	IIIB	IVB	VB	VIB	VIIIB	VIII B			IB	IIB	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		

Reading the Periodic Table: Classification

- Nonmetals, Metals, Metalloids, Noble gases

Nonmetals
 Metals
 Metalloids
 Noble gases

The metals, nonmetals, and metalloids

IA 1 H																VIII A 2 He		
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
		III B	IV B	V B	VI B	VII B	VIII B				I B	II B						
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub			114			116	118

Rare earth elements

Lanthanides	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
Actinides	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

Reading the Periodic Table: Categorization

Periods

- Each horizontal row of elements is called a period.
- The elements in a period are not alike in properties.
- In fact, the properties change greatly across even given row.
- The first element in a period is always an extremely active solid. The last element in a period, is always an inactive gas.

Reading the Periodic Table: Categorization

Families

- Columns of elements are called groups or families.
- Elements in each family have similar but not identical properties.
- For example, lithium (Li), sodium (Na), potassium (K), and other members of family IA are all soft, white, shiny metals.
- All elements in a family have the same number of valence electrons.

Reading the Periodic Table: Periodic Patterns

■ Period

- energy level (subtract for d & f)

■ A/B Group

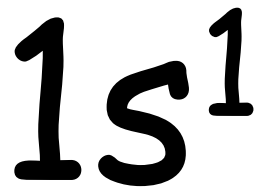
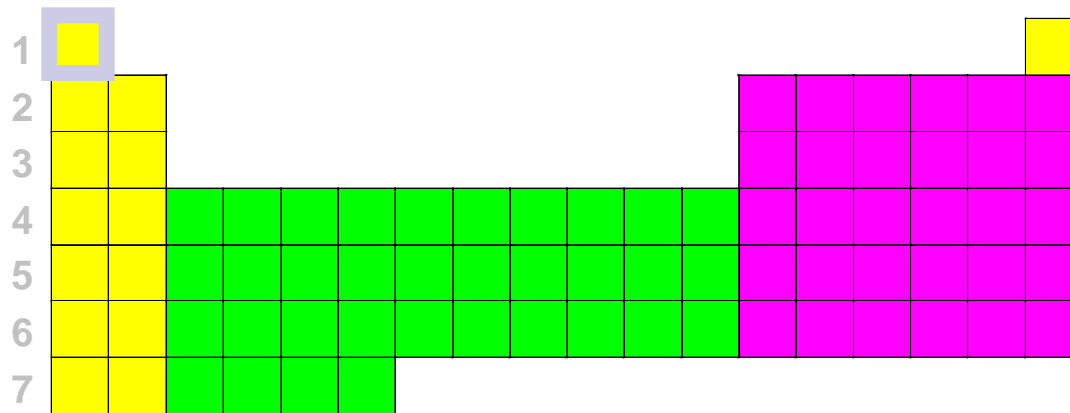
- total # of valence e^-

■ Column within sublevel block

- # of e^- in sublevel

Periodic Patterns

■ Example - Hydrogen



1st column
of s-block

1st Period

s-block

Periodic Table

e^- configuration from the periodic table

	1 IA	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	
1	H $1s^1$																		He $1s^2$
2	Li $2s^1$	Be $2s^2$											B $2p^1$	C $2p^2$	N $2p^3$	O $2p^4$	F $2p^5$	Ne $2p^6$	
3	Na $3s^1$	Mg $3s^2$	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIB	10	11 IB	12 IIB	Al $3p^1$	Si $3p^2$	P $3p^3$	S $3p^4$	Cl $3p^5$	Ar $3p^6$	
4	K $4s^1$	Ca $4s^2$	Sc $3d^1$	Ti $3d^2$	V $3d^3$	Cr $4s^1 3d^5$	Mn $3d^5$	Fe $3d^6$	Co $3d^7$	Ni $3d^8$	Cu $4s^1 3d^{10}$	Zn $3d^{10}$	Ga $4p^1$	Ge $4p^2$	As $4p^3$	Se $4p^4$	Br $4p^5$	Kr $4p^6$	
5	Rb $5s^1$	Sr $5s^2$	Y $4d^1$	Zr $4d^2$	Nb $4d^3$	Mo $5s^1 4d^5$	Tc $4d^5$	Ru $4d^6$	Rh $4d^7$	Ni $4d^8$	Ag $5s^1 4d^{10}$	Cd $4d^{10}$	In $5p^1$	Sn $5p^2$	Sb $5p^3$	Te $5p^4$	I $5p^5$	Xe $5p^6$	
6	Cs $6s^1$	Ba $6s^2$	La $5d^1$	Hf $5d^2$	Ta $5d^3$	W $6s^1 5d^5$	Re $5d^5$	Os $5d^6$	Ir $5d^7$	Ni $5d^8$	Au $6s^1 5d^{10}$	Hg $5d^{10}$	Tl $6p^1$	Pb $6p^2$	Bi $6p^3$	Po $6p^4$	At $6p^5$	Rn $6p^6$	
7	Fr $7s^1$	Ra $7s^2$	Ac $6d^1$	Rf $6d^2$	Db $6d^3$	Sg $7s^1 6d^5$	Bh $6d^5$	Hs $6d^6$	Mt $6d^7$										



Metals

Alkali Metals

- 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.



Alkaline Earth Metals

Periodic Table
of the Elements

- They are never found uncombined in nature.
- They have two valence electrons.
- Alkaline earth metals include magnesium and calcium, among others.

Properties of Metalloids



Silicon

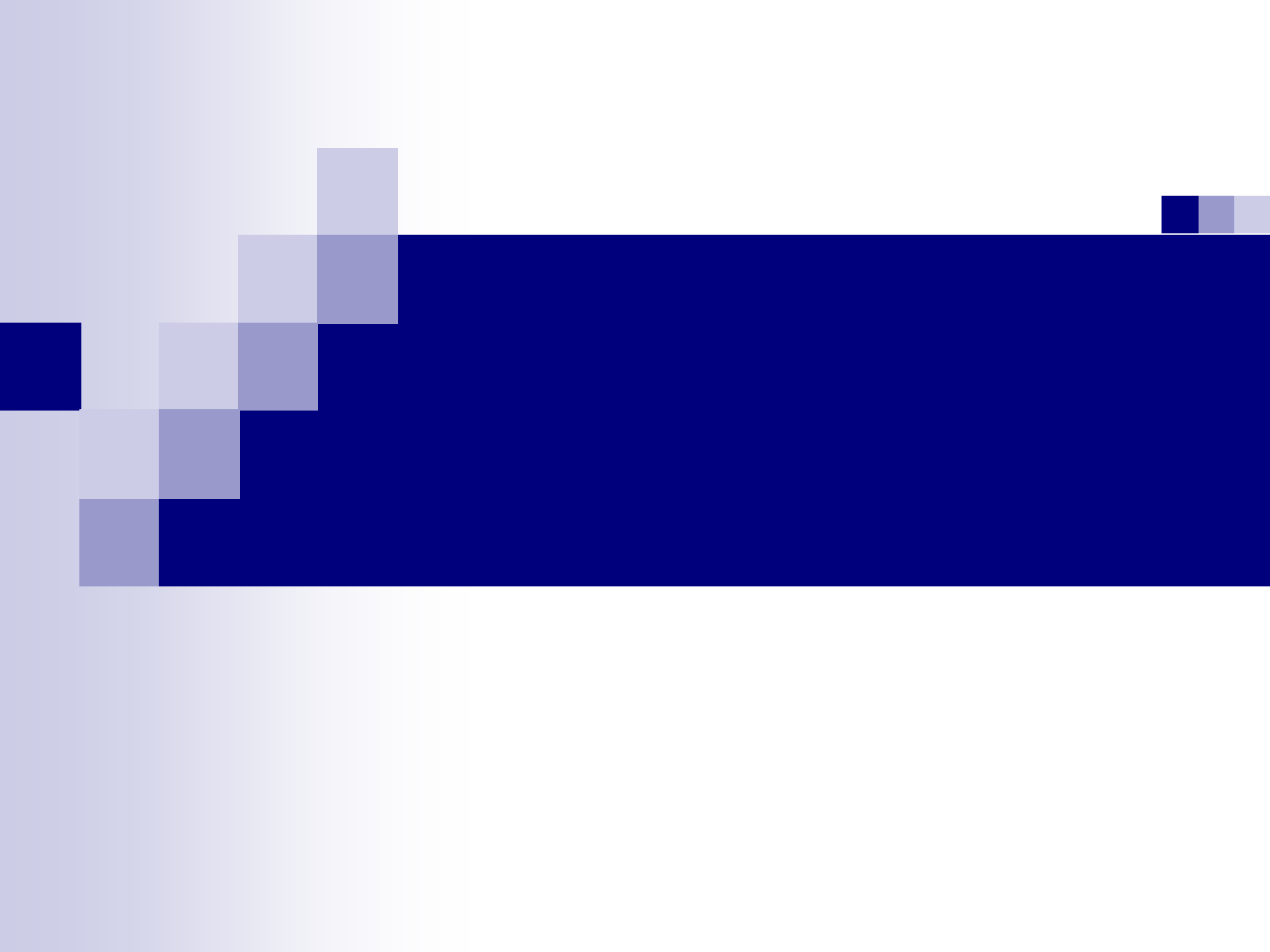
- Metalloids (metal-like) have properties of both metals and non-metals.
- They are solids that can be shiny or dull.
- They conduct heat and electricity better than non-metals but not as well as metals.
- They are ductile and malleable.

Transition Metals

Periodic Table
of the Elements

The diagram shows a simplified periodic table with a grid of 18 columns and 6 rows. The first two columns (groups 1 and 2) and the last two columns (groups 17 and 18) are shaded gray. The central 10 columns (groups 3 to 10) are highlighted in blue, representing the transition metals. The bottom row is a separate block of 10 gray cells, representing the lanthanide and actinide series.

- Transition Elements include those elements in the B families.
- These are the metals you are probably most familiar: copper, tin, zinc, iron, nickel, gold, and silver.
- They are good conductors of heat and electricity.



Transition Elements

- Transition elements have properties similar to one another and to other metals, but their properties do not fit in with those of any other family.
- Many transition metals combine chemically with oxygen to form compounds called oxides.

Properties of Non-Metals



Sulfur

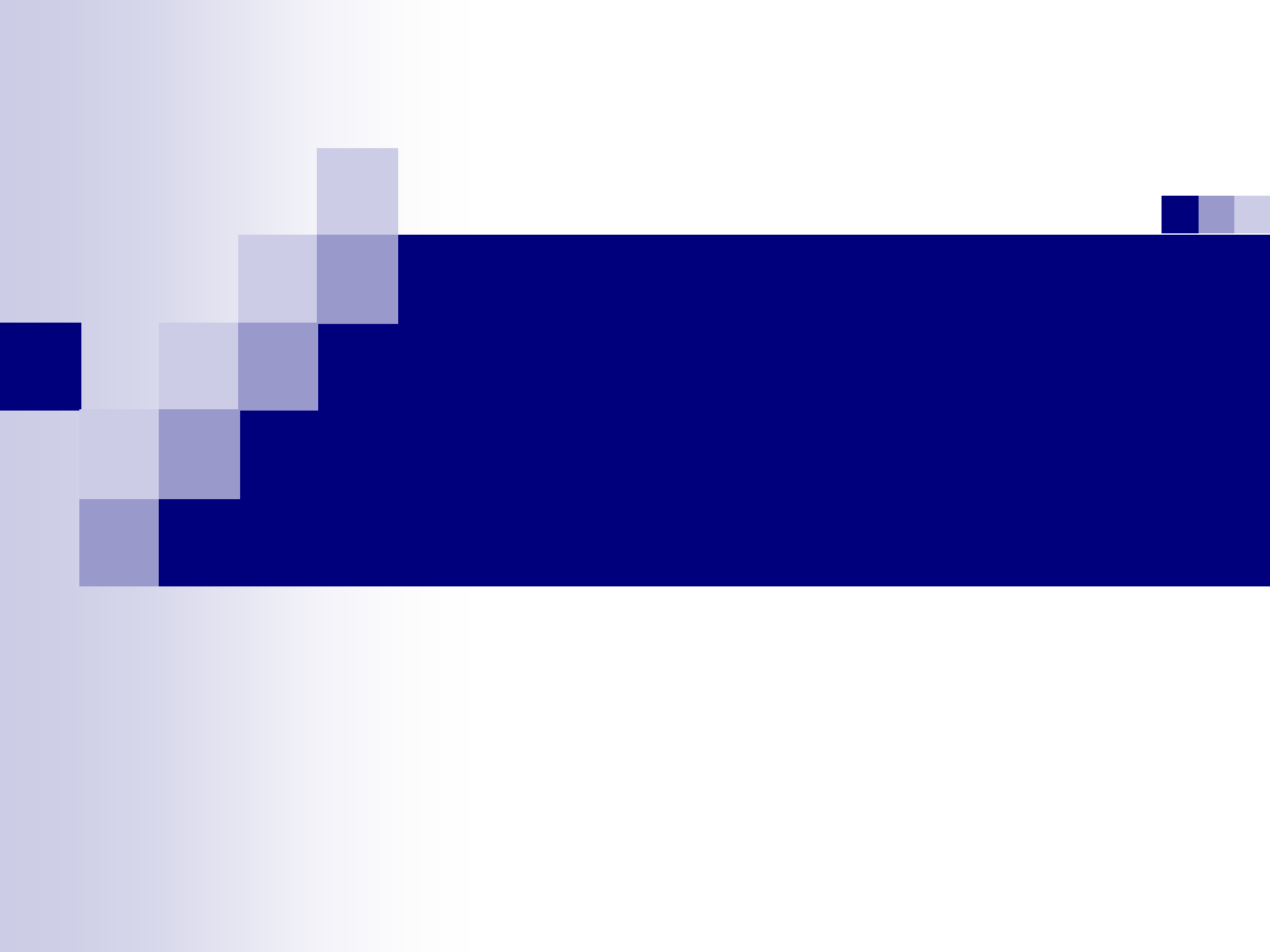
- Non-metals are poor conductors of heat and electricity.
- Non-metals are not ductile or malleable.
- Solid non-metals are brittle and break easily.
- They are dull.
- Many non-metals are gases.

Carbon Family

- Atoms of this family have 4 valence electrons.
- This family includes a non-metal (carbon), metalloids, 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 image shows a simplified periodic table of elements. The elements are represented by a grid of squares. The title 'Periodic Table of the Elements' is centered above the grid. A vertical column of four squares, representing the carbon family (Group 14), is highlighted in yellow. This column is located in the second column from the right of the main body of the table. Below the main grid, there is a separate horizontal row of 10 squares, 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 of elements. The main body of the table is a grid of 18 columns and 4 rows. The first two columns are on the left, and the last two are on the right. A vertical column of six elements is highlighted in dark blue, representing the Oxygen Family (Group 16). Below the main table is a separate row of 18 elements, representing the lanthanide and actinide series.

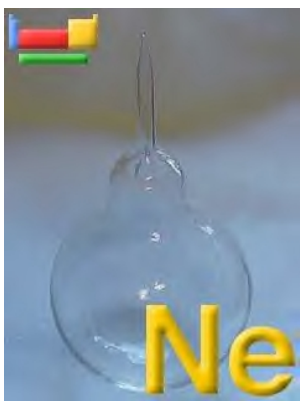
Halogen Family

- The elements in this family are fluorine, chlorine, bromine, iodine, and astatine.
- Halogens have 7 valence electrons, which explains why they are the most active non-metals. They are never found free in nature.

Periodic Table of the Elements

The image shows a simplified periodic table with a grid of cells. The cells are shaded gray. The halogen family, consisting of fluorine, chlorine, bromine, iodine, and astatine, is highlighted in yellow. These elements are located in the second, third, fourth, fifth, and sixth periods of the table, respectively, in the seventh column from the left. The title 'Periodic Table of the Elements' is centered above the grid.

Halogen atoms only need to gain 1 electron to fill their outermost energy level. They react with alkali metals to form salts.



Noble Gases

Periodic Table
of the Elements

- Noble Gases are colorless gases that are extremely un-reactive.
- One important property of the noble gases is their inactivity. They are inactive because their outermost energy level is full.
- Because they do not readily combine with other elements to form compounds, the noble gases are called inert.
- The family of noble gases includes helium, neon, argon, krypton, xenon, and radon.
- All the noble gases are found in small amounts in the earth's atmosphere.

Rare Earth Elements

Periodic Table
of the Elements

The diagram shows a simplified periodic table with a grid of 18 columns and 7 rows. The first two columns are on the left, and the last two are on the right. The middle 14 columns are connected by a horizontal line. Below this grid is a separate row of 14 blue boxes, representing the lanthanide and actinide series.

- 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 Trends

Electronegativity - a chemical property describing an atom's ability to attract and bind with electrons.

Atomic Radius - a term used to describe the size of the atom. There is no standard definition for this value - it may refer to the ionic radius, covalent radius, metallic radius, or van der Waals radius.

Ionization potential (ionization energy (E_i)) - is qualitatively defined as the minimum amount of energy required to remove the most loosely bound electron, the valence electron, of an isolated neutral gaseous atom to form a cation.

Electron Affinity - the **electron affinity (E_{ea})** of an atom or molecule is defined as the amount of energy *released* or *spent* when an electron is added to a neutral atom or molecule in the gaseous state to form a negative ion.

Melting Point - the amount of energy required to break a bond(s) to change the solid phase of a substance to a liquid.

1. Trend in Electronegativity

- From left to right across a period of elements, electronegativity increases.
- From top to bottom down a group, electronegativity decreases.
- Important exceptions of the above rules include the noble gases, lanthanides, and actinides.
- As for the transition metals, although they have electronegativity values, there is little variance among them across the period and up and down a group.

INCREASING ELECTRONEGATIVITY

←																		→					
1 H Hydrogen 1.00794																	2 He Helium 4.003						
3 Li Lithium 0.941	4 Be Beryllium 9.012182																	5 B Boron 10.811	6 C Carbon 2.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050																	13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80						
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29						
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)						
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	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	111 (269)	112 (271)	113	114										

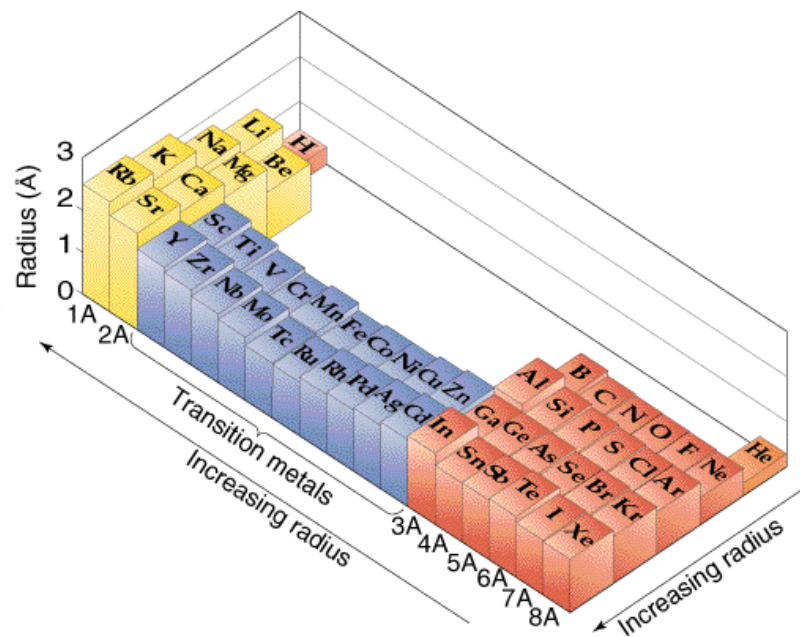
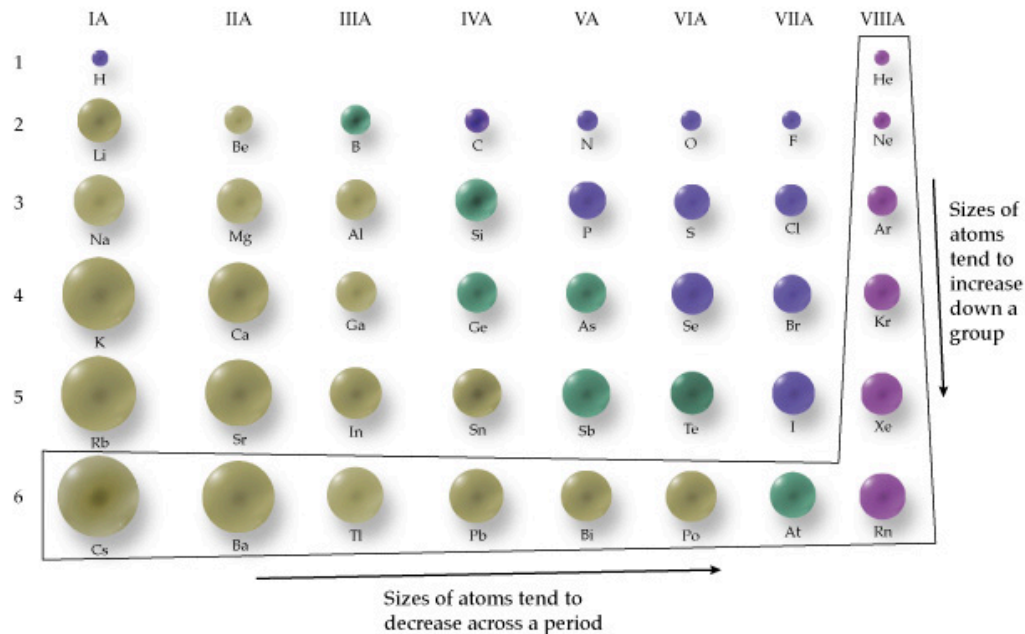
INCREASING ELECTRONEGATIVITY

2. Trend in Atomic Radius

■ Atomic Radius:

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

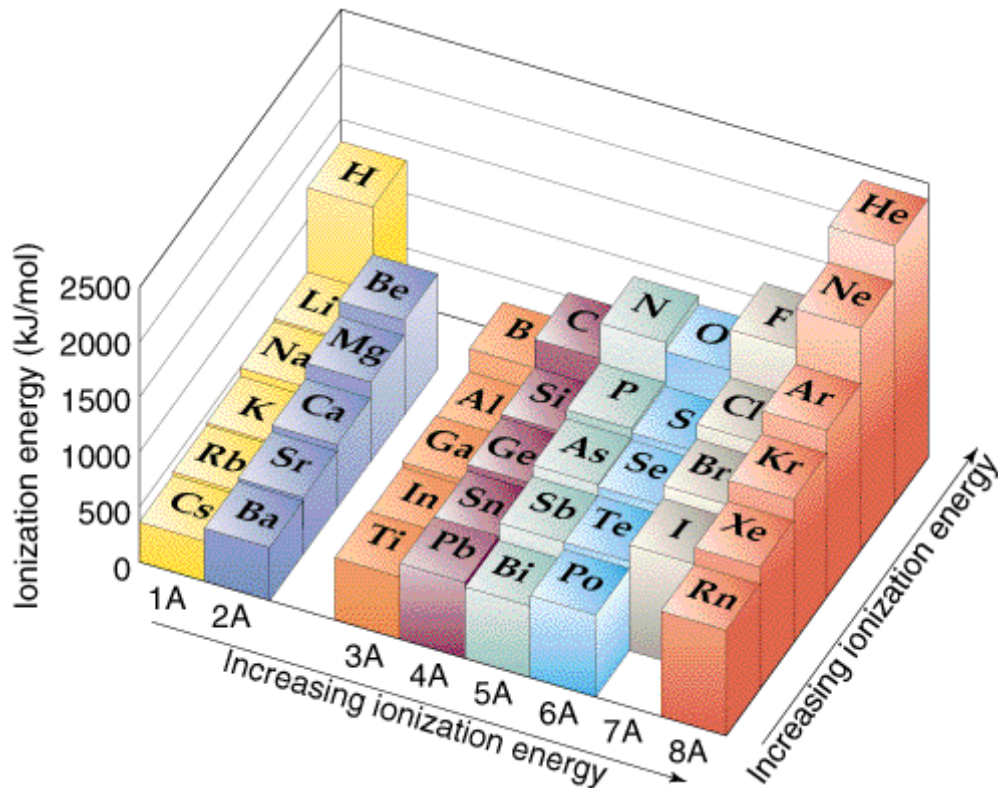
Relative Atomic Sizes of the Representative Elements



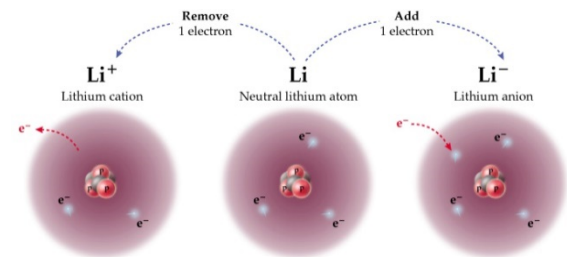
3. Trend in Ionization Potential

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



4. 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

5. Trend in Melting point

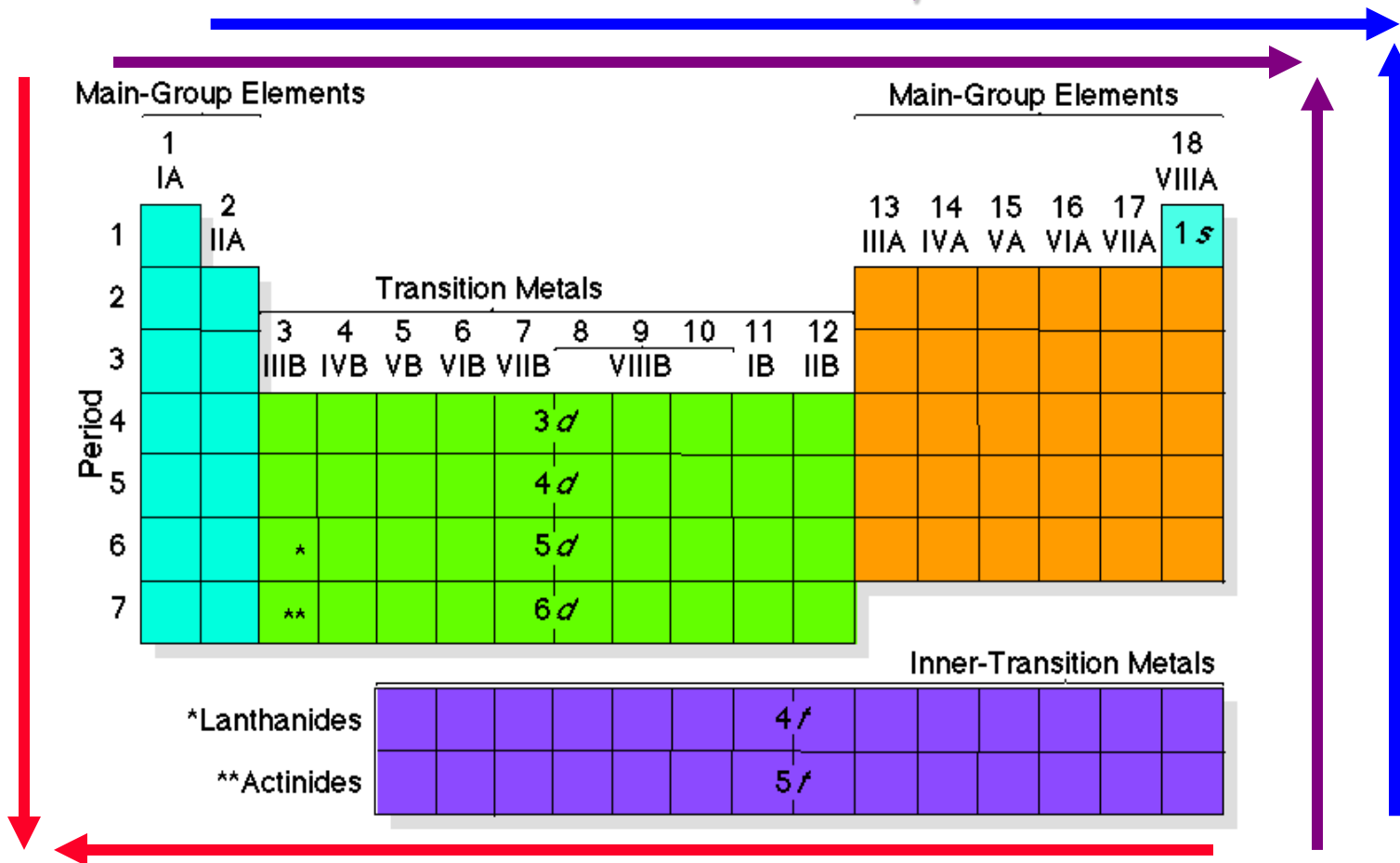
Melting points are varied and do not generally form a distinguishable trend across the periodic table. However, certain conclusions can be drawn from the graph below.

- ❑ Metals generally possess a *high melting point*.
- ❑ Most non-metals possess *low melting points*.
- ❑ The non-metal **carbon** possesses the *highest boiling point of all the elements*. The semi-metal boron also possesses a high melting point.

Summary of Trend

- Periodic Table and Periodic Trends

Ionization Energy: Largest toward NE of PT
 Electron Affinity: Most favorable NE of PT



Atomic Radius: Largest toward SW corner of PT