

# **Chapter 5: The Periodic Law**

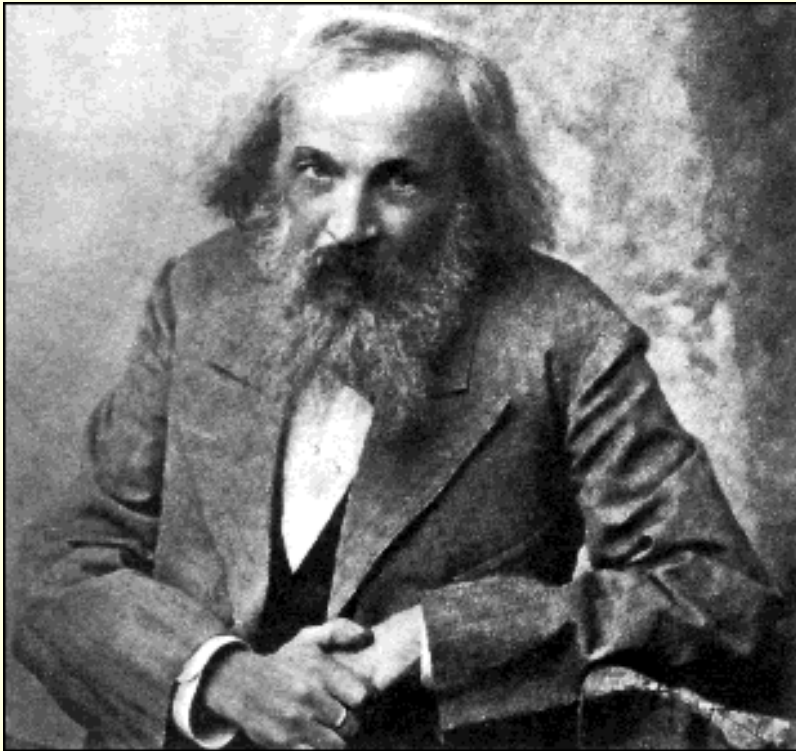
## Section 5.1:

# The History of the Periodic Table

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- **Dmitri Mendeleev (1869)** – first person to organize the elements in a chart
- Organized about 70 elements by increasing atomic mass
- Left blank spaces for elements which were not discovered yet

# Mendeleev's Periodic Table



## ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ 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 = 106,8	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 = 35,5	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133
		Ca = 40	Sr = 87,6	Ba = 137
		? = 45	Ce = 92	Pb = 207.
		?Er = 56	La = 94	
		?Yt = 60	Di = 95	
		?In = 75,6	Th = 118?	

Д. Менделѣевъ

# Periodic Table

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**Henry Moseley (1911)** –  
rearranged Mendeleev's  
periodic table to the  
current configuration  
Arranged by increasing  
atomic number instead!  
Also grouped elements by  
their properties



# Periodic Law

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*When the elements are arranged in order of increasing atomic number, there is a periodic repetition of their physical and chemical properties.*

# The Modern Periodic Table

Periodic table of the elements

period	group											13	14	15	16	17	18		
	1*											IIIa	IVa	Va	VIa	VIIa	0		
	Ia**																		
1	H																He		
2	Li	Be											B	C	N	O	F	Ne	
3	Na	Mg	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
			IIIb	IVb	Vb	VIb	VIIb	VIIIb		IXb	Xb	IIb	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	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	(Uub)	(Uut)	(Uuq)	(Uup)	(Uuh)			
lanthanide series			6	58	59	60	61	62	63	64	65	66	67	68	69	70	71		
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
actinide series			7	90	91	92	93	94	95	96	97	98	99	100	101	102	103		
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

\* Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).

\*\* Numbering system widely used, especially in the U.S., from the mid-20th century.

\*\*\* Discoveries of elements 112–116 are claimed but not confirmed. Element names and symbols in parentheses are temporarily assigned by IUPAC.

# The Modern Periodic Table

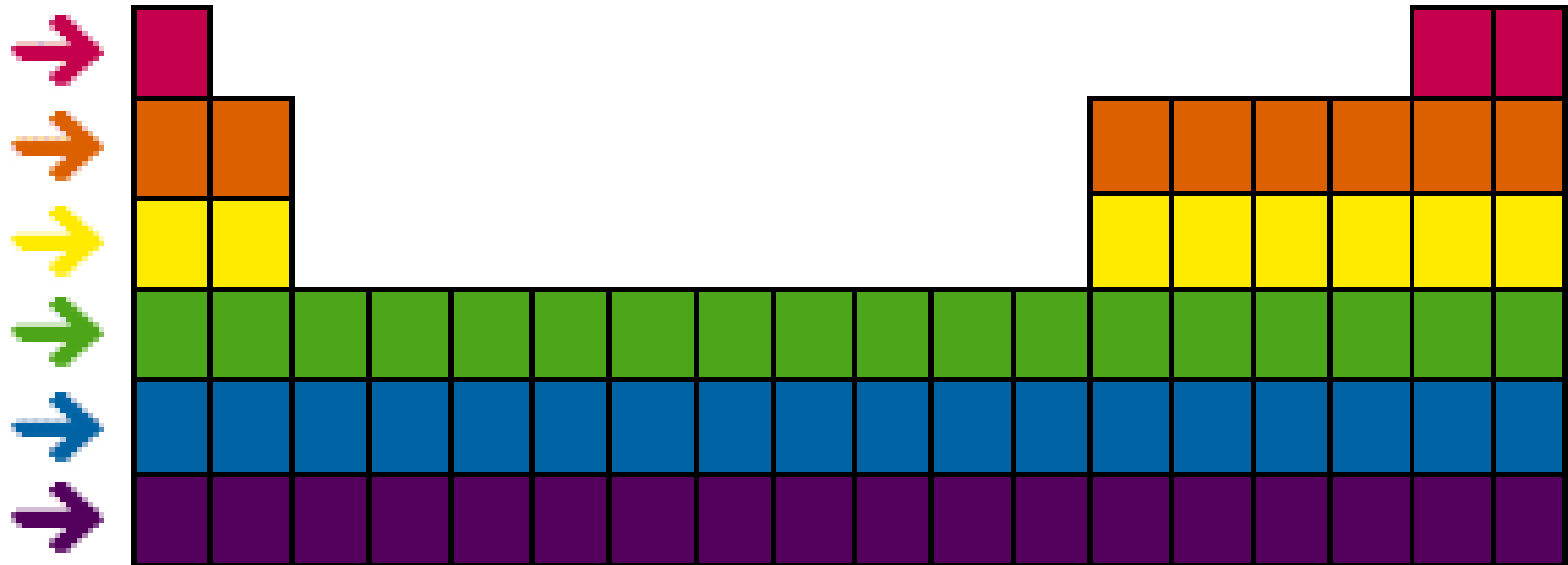
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## Periods:

- The horizontal rows of the table: there are 7 periods
- Properties change as you move across a period
- Properties repeat in a new period

# The Modern Periodic Table

## PERIODS



The elements range from atomic number 1 to 113



# The Modern Periodic Table

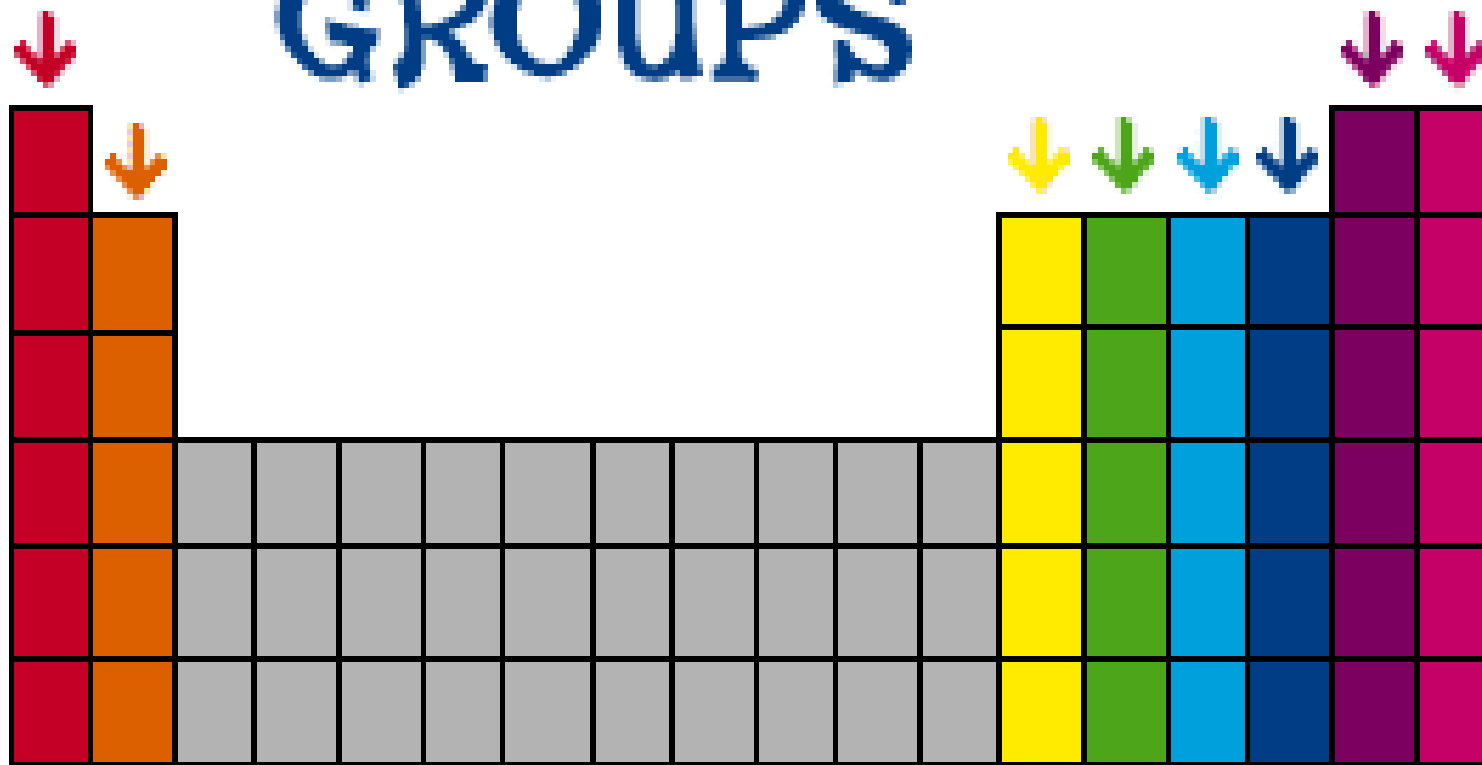
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## Groups:

- The vertical columns on the table (also called families)
- The elements in a group have similar physical and chemical properties
- Each group has a letter and a number

# The Modern Periodic Table

## GROUPS



- Group A Main Group elements
- Group B Transition elements

# The Modern Periodic Table

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Main group elements are divided into three groups:

1. Metals
2. Nonmetals
3. Metalloids

# Metals

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1. Have high electrical conductivity
2. Have high luster
3. Are ductile: they can be drawn into wires
4. They are malleable: can be formed into shapes

# Groups of the Periodic Table

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## Group 1 = Alkali Metals

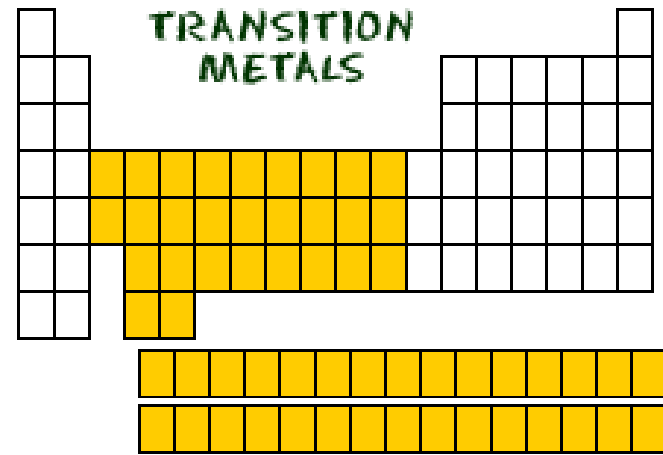
- Violently react with water
- <http://video.google.com/videoplay?docid=-2134266654801392897>

## Group 2 = Alkaline Earth Metals

- Very common in the earth's surface

# Groups of the Periodic Table

- Group 3-12 = Transition Metals
  - Most of the common metals
- Lanthanide & Actinide Series = Inner Transition Metals



# Groups of the Periodic Table

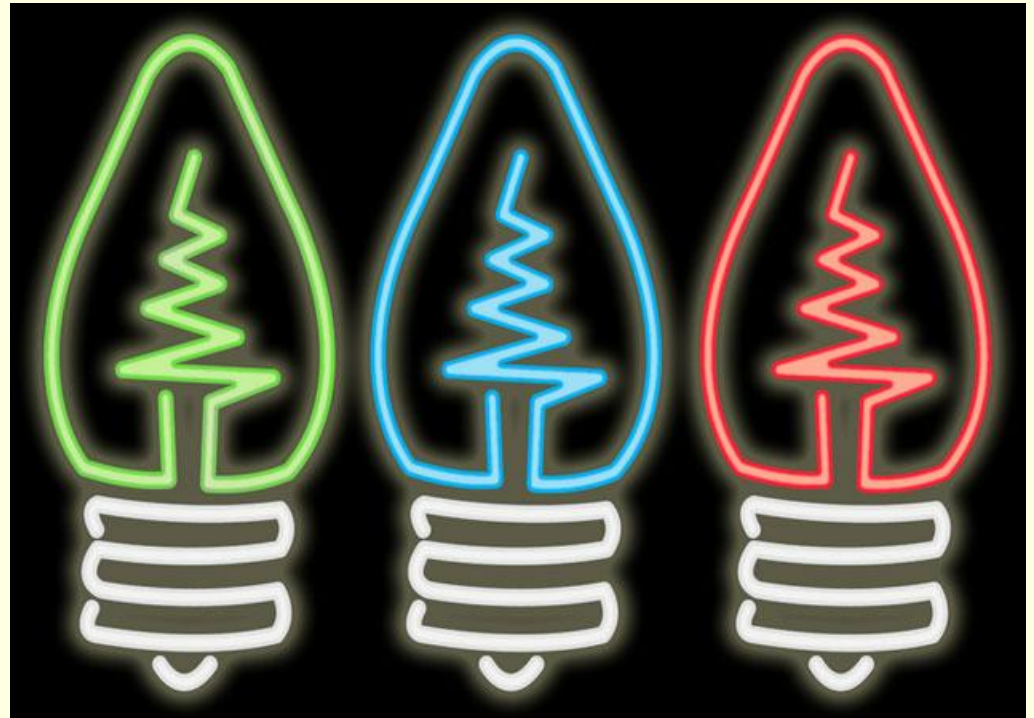
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- Group 13-16: Either metals, metalloids, or nonmetal
  - Depends on line of demarcation
- Group 17: Halogens
  - Highly reactive
    - Fluorine
    - Chlorine
    - Bromine
    - Iodine



# Groups of the Periodic Table

- Group 18: Noble Gases
  - All gases
  - Do not react or combine with any other element





# Nonmetals

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1. Non-lustrous elements
2. Generally poor conductors of electricity
3. Located in the upper right-hand corner of the table

# Metalloids

---

- Elements that border the line between metals and the nonmetals
- Elements with properties are intermediate between those of metals and nonmetals
- Examples: silicon and boron

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	110 110	111 111	112 112	113 113					

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

	<b>Non-metals</b>
	<b>Metals</b>
	<b>Metalloids</b>

# Periodic Table of Elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																
1	<b>H</b> Hydrogen 1.00794	Atomic # Symbol Name Atomic Mass																	2	<b>He</b> Helium 4.002602																														
2	<b>Li</b> Lithium 6.941	<b>Be</b> Beryllium 9.012182	<table border="1"> <tr> <td><b>C</b> Solid</td> <td colspan="4"><b>Metals</b></td> <td colspan="3"><b>Nonmetals</b></td> </tr> <tr> <td><b>Hg</b> Liquid</td> <td><b>Alkali metals</b></td> <td><b>Alkaline earth metals</b></td> <td><b>Lanthanoids</b></td> <td><b>Transition metals</b></td> <td><b>Poor metals</b></td> <td><b>Other nonmetals</b></td> <td><b>Noble gases</b></td> </tr> <tr> <td><b>H</b> Gas</td> <td></td> <td></td> <td><b>Actinoids</b></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td><b>Rf</b> Unknown</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>										<b>C</b> Solid	<b>Metals</b>				<b>Nonmetals</b>			<b>Hg</b> Liquid	<b>Alkali metals</b>	<b>Alkaline earth metals</b>	<b>Lanthanoids</b>	<b>Transition metals</b>	<b>Poor metals</b>	<b>Other nonmetals</b>	<b>Noble gases</b>	<b>H</b> Gas			<b>Actinoids</b>					<b>Rf</b> Unknown								<b>B</b> Boron 10.811	<b>C</b> Carbon 12.0107	<b>N</b> Nitrogen 14.0067	<b>O</b> Oxygen 15.9994	<b>F</b> Fluorine 18.9984032	<b>Ne</b> Neon 20.1797
<b>C</b> Solid	<b>Metals</b>				<b>Nonmetals</b>																																													
<b>Hg</b> Liquid	<b>Alkali metals</b>	<b>Alkaline earth metals</b>	<b>Lanthanoids</b>	<b>Transition metals</b>	<b>Poor metals</b>	<b>Other nonmetals</b>	<b>Noble gases</b>																																											
<b>H</b> Gas			<b>Actinoids</b>																																															
<b>Rf</b> Unknown																																																		
3	<b>Na</b> Sodium 22.98976928	<b>Mg</b> Magnesium 24.3050											<b>Al</b> Aluminium 26.9815386	<b>Si</b> Silicon 28.0855	<b>P</b> Phosphorus 30.973762	<b>S</b> Sulfur 32.065	<b>Cl</b> Chlorine 35.453	<b>Ar</b> Argon 39.948																																
4	<b>K</b> Potassium 39.0983	<b>Ca</b> Calcium 40.078	<b>Sc</b> Scandium 44.955912	<b>Ti</b> Titanium 47.887	<b>V</b> Vanadium 50.9415	<b>Cr</b> Chromium 51.9961	<b>Mn</b> Manganese 54.938045	<b>Fe</b> Iron 55.845	<b>Co</b> Cobalt 58.933195	<b>Ni</b> Nickel 58.6934	<b>Cu</b> Copper 63.546	<b>Zn</b> Zinc 65.38	<b>Ga</b> Gallium 69.723	<b>Ge</b> Germanium 72.64	<b>As</b> Arsenic 74.92160	<b>Se</b> Selenium 78.96	<b>Br</b> Bromine 79.904	<b>Kr</b> Krypton 83.798																																
5	<b>Rb</b> Rubidium 85.4678	<b>Sr</b> Strontium 87.62	<b>Y</b> Yttrium 88.90585	<b>Zr</b> Zirconium 91.224	<b>Nb</b> Niobium 92.90638	<b>Mo</b> Molybdenum 95.96	<b>Tc</b> Technetium (97.9072)	<b>Ru</b> Ruthenium 101.07	<b>Rh</b> Rhodium 102.90550	<b>Pd</b> Palladium 106.42	<b>Ag</b> Silver 107.8682	<b>Cd</b> Cadmium 112.411	<b>In</b> Indium 114.818	<b>Sn</b> Tin 118.710	<b>Sb</b> Antimony 121.760	<b>Te</b> Tellurium 127.60	<b>I</b> Iodine 126.90447	<b>Xe</b> Xenon 131.293																																
6	<b>Cs</b> Caesium 132.9054519	<b>Ba</b> Barium 137.327	57–71	<b>Hf</b> Hafnium 178.49	<b>Ta</b> Tantalum 180.94788	<b>W</b> Tungsten 183.84	<b>Re</b> Rhenium 186.207	<b>Os</b> Osmium 190.23	<b>Ir</b> Iridium 192.217	<b>Pt</b> Platinum 195.084	<b>Au</b> Gold 196.966569	<b>Hg</b> Mercury 200.59	<b>Tl</b> Thallium 204.3833	<b>Pb</b> Lead 207.2	<b>Bi</b> Bismuth 208.98040	<b>Po</b> Polonium (208.9824)	<b>At</b> Astatine (209.9871)	<b>Rn</b> Radon (222.0176)																																
7	<b>Fr</b> Francium (223)	<b>Ra</b> Radium (226)	89–103	<b>Rf</b> Rutherfordium (261)	<b>Db</b> Dubnium (262)	<b>Sg</b> Seaborgium (266)	<b>Bh</b> Bohrium (264)	<b>Hs</b> Hassium (277)	<b>Mt</b> Meitnerium (268)	<b>Ds</b> Darmstadtium (271)	<b>Rg</b> Roentgenium (272)	<b>Uub</b> Ununbium (285)	<b>Uut</b> Ununtrium (284)	<b>Uuq</b> Ununquadium (289)	<b>Uup</b> Ununpentium (288)	<b>Uuh</b> Ununhexium (292)	<b>Uus</b> Ununseptium	<b>Uuo</b> Ununoctium (294)																																

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

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<b>57 La</b> Lanthanum 138.90547	<b>58 Ce</b> Cerium 140.116	<b>59 Pr</b> Praseodymium 140.90795	<b>60 Nd</b> Neodymium 144.242	<b>61 Pm</b> Promethium (145)	<b>62 Sm</b> Samarium 150.36	<b>63 Eu</b> Europium 151.964	<b>64 Gd</b> Gadolinium 157.25	<b>65 Tb</b> Terbium 158.92535	<b>66 Dy</b> Dysprosium 162.500	<b>67 Ho</b> Holmium 164.93032	<b>68 Er</b> Erbium 167.259	<b>69 Tm</b> Thulium 168.93421	<b>70 Yb</b> Ytterbium 173.054	<b>71 Lu</b> Lutetium 174.9668
<b>89 Ac</b> Actinium (227)	<b>90 Th</b> Thorium 232.03806	<b>91 Pa</b> Protactinium 231.03688	<b>92 U</b> Uranium 238.02891	<b>93 Np</b> Neptunium (237)	<b>94 Pu</b> Plutonium (244)	<b>95 Am</b> Americium (243)	<b>96 Cm</b> Curium (247)	<b>97 Bk</b> Berkelium (247)	<b>98 Cf</b> Californium (251)	<b>99 Es</b> Einsteinium (252)	<b>100 Fm</b> Fermium (257)	<b>101 Md</b> Mendelevium (258)	<b>102 No</b> Nobelium (259)	<b>103 Lr</b> Lawrencium (262)

# Section 5.2: e<sup>-</sup> Configurations & the Periodic Table

- Each group on the periodic table has the same ending electron configuration

## Periodic Table of Elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																			
1	<b>H</b> Hydrogen 1.00794																		2	<b>He</b> Helium 4.002602																	
3	<b>Li</b> Lithium 6.941	4	<b>Be</b> Beryllium 9.012182															10	<b>Ne</b> Neon 20.1797																		
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19	<b>K</b> Potassium 39.0983	20	<b>Ca</b> Calcium 40.078	21	<b>Sc</b> Scandium 44.955912	22	<b>Ti</b> Titanium 47.887	23	<b>V</b> Vanadium 50.9415	24	<b>Cr</b> Chromium 51.9961	25	<b>Mn</b> Manganese 54.938045	26	<b>Fe</b> Iron 55.845	27	<b>Co</b> Cobalt 58.933195	28	<b>Ni</b> Nickel 58.6934	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 72.64	33	<b>As</b> Arsenic 74.92160	34	<b>Se</b> Selenium 78.96	35	<b>Br</b> Bromine 79.904	36	<b>Kr</b> Krypton 83.798		
37	<b>Rb</b> Rubidium 85.4678	38	<b>Sr</b> Strontium 87.62	39	<b>Y</b> Yttrium 88.90585	40	<b>Zr</b> Zirconium 91.224	41	<b>Nb</b> Niobium 92.90638	42	<b>Mo</b> Molybdenum 95.96	43	<b>Tc</b> Technetium 98.9062	44	<b>Ru</b> Ruthenium 101.07	45	<b>Rh</b> Rhodium 102.90550	46	<b>Pd</b> Palladium 106.42	47	<b>Ag</b> Silver 107.8682	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 127.60	53	<b>I</b> Iodine 126.90547	54	<b>Xe</b> Xenon 131.293		
55	<b>Cs</b> Cesium 132.9054519	56	<b>Ba</b> Barium 137.327	57-71												82	<b>Pb</b> Lead 208.2866	83	<b>Bi</b> Bismuth 208.98040	84	<b>Po</b> Polonium (209)	85	<b>At</b> Astatine (209)	86	<b>Rn</b> Radon (222)												
87	<b>Fr</b> Francium (223)	88	<b>Ra</b> Radium (226)	89-103												110	<b>Ds</b> Darmstadtium (271)	111	<b>Rg</b> Roentgenium (272)	112	<b>Uub</b> Ununbium (285)	113	<b>Uut</b> Ununtrium (288)	114	<b>Uuq</b> Ununquadium (289)	115	<b>Uup</b> Ununpentium (288)	116	<b>Uuh</b> Ununhexium (288)	117	<b>Uus</b> Ununseptium (288)	118	<b>Uuo</b> Ununoctium (294)				
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																			Design and Interface Copyright © 1997 Michael Dayah (michael@dayah.com). <a href="http://www.ptable.com/">http://www.ptable.com/</a>																		
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89	<b>Ac</b> Actinium (227)	90	<b>Th</b> Thorium 232.03806	91	<b>Pa</b> Protactinium 231.03688	92	<b>U</b> Uranium 238.02891	93	<b>Np</b> Neptunium (237)	94	<b>Pu</b> Plutonium (244)	95	<b>Am</b> Americium (243)	96	<b>Cm</b> Curium (247)	97	<b>Bk</b> Berkelium (247)	98	<b>Cf</b> Californium (251)	99	<b>Es</b> Einsteinium (252)	100	<b>Fm</b> Fermium (257)	101	<b>Md</b> Mendelevium (258)	102	<b>No</b> Nobelium (259)	103	<b>Lr</b> Lawrencium (262)								

# Block Diagram

*s*-Block

H

He

Li	Be
Na	Mg
K	Ca
Rb	Sr
Cs	Ba
Fr	Ra

*d*-Block

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
Ac**	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub

*p*-Block

B	C	N	O	F	Ne
Al	Si	P	S	Cl	Ar
Ga	Ge	As	Se	Br	Kr
In	Sn	Sb	Te	I	Xe
Tl	Pb	Bi	Po	At	Rn
	Uuq				

*f*-Block

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

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# Section 5.3 – Electron Configurations and Periodic Properties

**5 Trends to KNOW!**

# Trends to Know

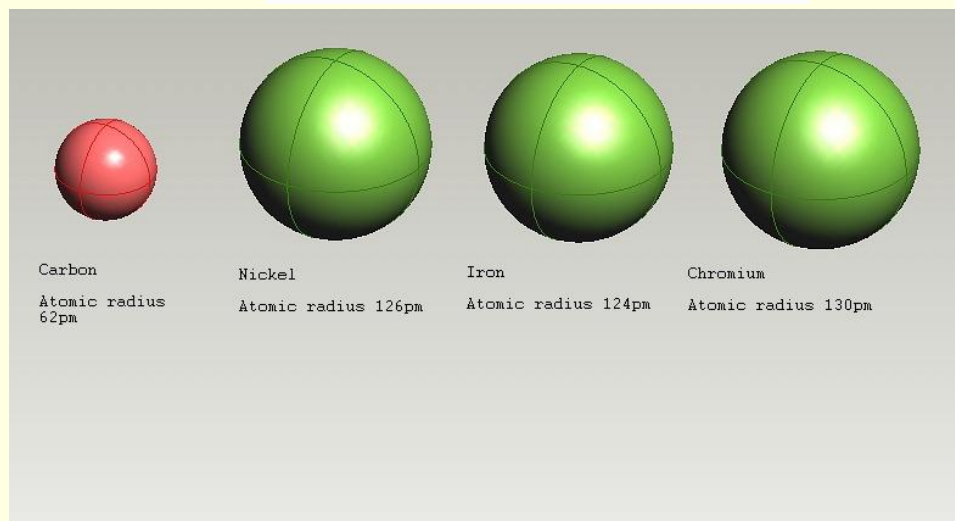
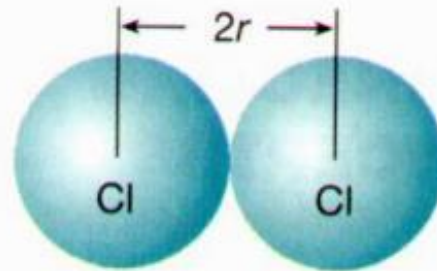
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- 1. Atomic radius
- 2. Ionization energy
- 3. Electron affinity
- 4. Ionic Radius
- 5. Electronegativity



# 1. Atomic Radius

**Atomic Radius:** half of the distance between the nuclei of two atoms in a homonuclear diatomic molecule



# 1. Atomic Radius

---

As you travel down a group  
(↓): atomic radius generally  
increases

- Because: *e- are added to higher energy levels, further away from the nucleus*

# 1. Atomic Radius

---

As you travel across a period (→): Atomic radius generally decreases

- Because: *e- are added to the same energy level and the more positive nucleus pulls on them more strongly*
  - Trend is less pronounced in atoms with more electrons in the occupied energy level (d and f) because of the **shielding effect**
  - Definition: *Inner electrons help protect outer electrons from the effect of the nucleus*

DECREASING ATOMIC RADIUS

I

II

III

IV

V

VI

VII

VIII



H



He



Li



Be



B



C



N



O



F



Ne



Na



Mg



Al



Si



P



S



Cl



Ar



K



Ca



Ga



Ge



As



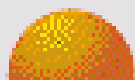
Se



Br



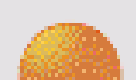
Kr



Rb



Sr



In



Sn



Sb



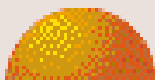
Te



I



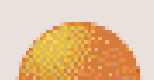
Xe



Cs



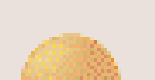
Ba



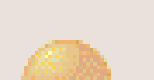
Tl



Pb



Bi



Po



At



Rn

INCREASING ATOMIC RADIUS

# Your Turn:

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Put these elements in order of increasing atomic radius

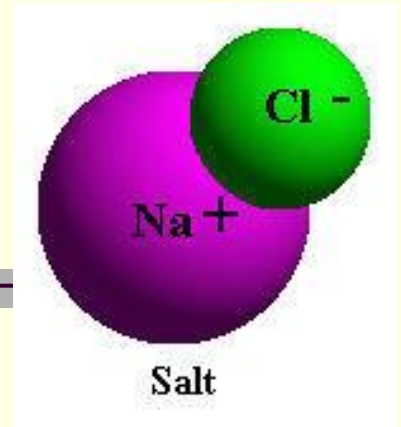
- C N Li F O

- What is the trend?

- Answer: Li > C > N > O > F

## 2. Ions

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- Ions = charged atoms
  - Have different numbers of electrons
- Cations = positively charged atoms
  - have less electrons than protons
- Anions = negatively charged atoms
  - Have more electrons than protons

## 2. Ionization Energy

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- **Ionization Energy:** the energy needed to remove an electron from a neutral atom, forming a positive ion
  - **first ionization energy:** energy required to remove the first outermost electron
  - **second ionization energy:** energy required to remove an electron from a  $1^+$  ion, making it a  $2^+$  ion (Table 3 p 155)

## 2. Ionization Energy

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As you travel down a group (↓):  
the first ionization energy  
***decrease***

- *Because:* *the atoms are larger, thus easier to remove an electron*



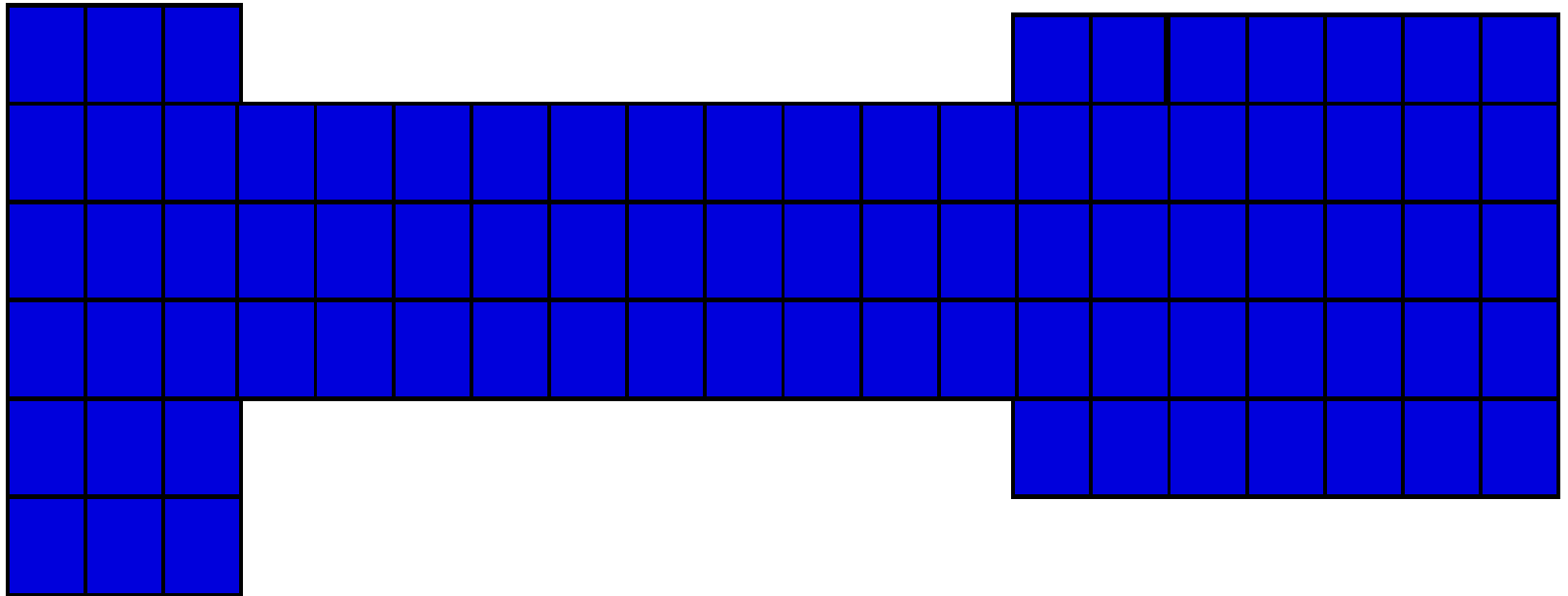
## 2. Ionization Energy

---

As you travel across a period ( $\rightarrow$ ) -  
for representative elements, the  
1st ionization energy generally  
**increases**

- Because: *Greater nuclear charge, thus more attraction and harder to remove the electron*

# Ionization Energy Increases With Arrows



# Your Turn:

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Put these elements in order of decreasing ionization energy

- C N Li F O

- What is the trend?

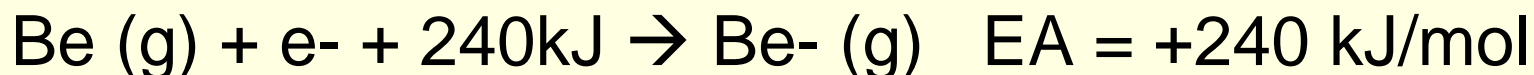
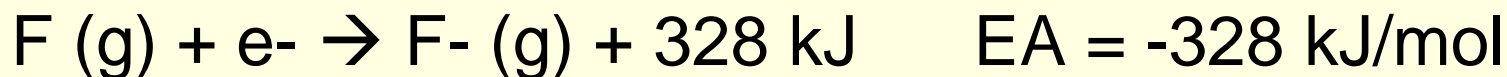
- Answer: F > O > N > C > Li

# 3. Electron Affinity

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**Electron Affinity:** the energy change that accompanies the addition of an electron to a neutral atom, forming a negative ion (**anion**)

- Most elements release energy when they gain an electron, making the value of electron affinities negative.



# 3. Electron Affinity

---

As you travel down a group (↓):

electron affinities generally decrease: so  
*electron energy becomes less negative*

■ **Because:** *radius is bigger and the pull of the nucleus is not as strong to add e-*

■ noble gases do not attract any electrons

(Remember that energy given off is denoted as a negative value!)

# 3. Electron Affinity

---

As you travel across a period →: Electron affinities generally **increase** (easier to add e-), so the value becomes more negative

- Because: *radius is smaller and the pull of the nucleus is stronger on e-*

Electron Affinity Increases

Electron Affinity Increases

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
H 73.5	*					H 73.5	He *
Li 60.4	Be *	B 27	C 123.4	N -7	O 142.5	F 331.4	Ne *
Na 53.2	Mg *	Al 45	Si 135.0	P 72.4	S 202.5	Cl 352.4	Ar *
K 48.9	Ca *	Ga 30	Ge 120	As 78	Se 197.0	Br 327.9	Kr *
Rb 47.4	Sr *	In 29	Sn 122	Sb 102	Te 192.1	I 298.4	Xe *
Cs 46.0	Ba *	Tl 30	Pb 110	Bi 110	Po 190	At 270	Rn *
Fr 44.5	Ra *						

# Your Turn:

---

Put these elements in order of increasing electron affinity

- C N Li F O

- What is the trend?

- Answer: Li > C > N > O > F

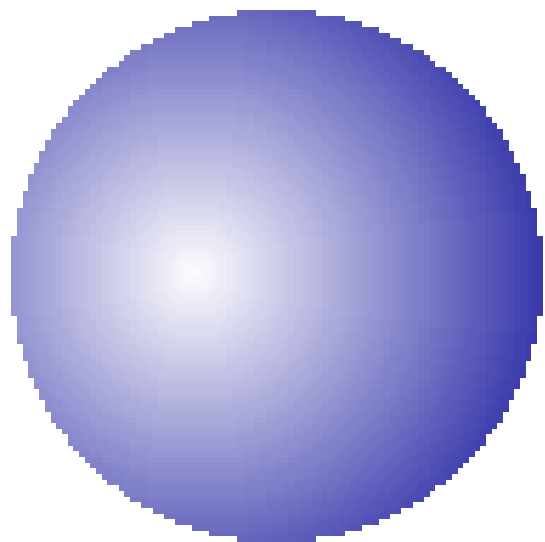


## 4. Ionic Radii

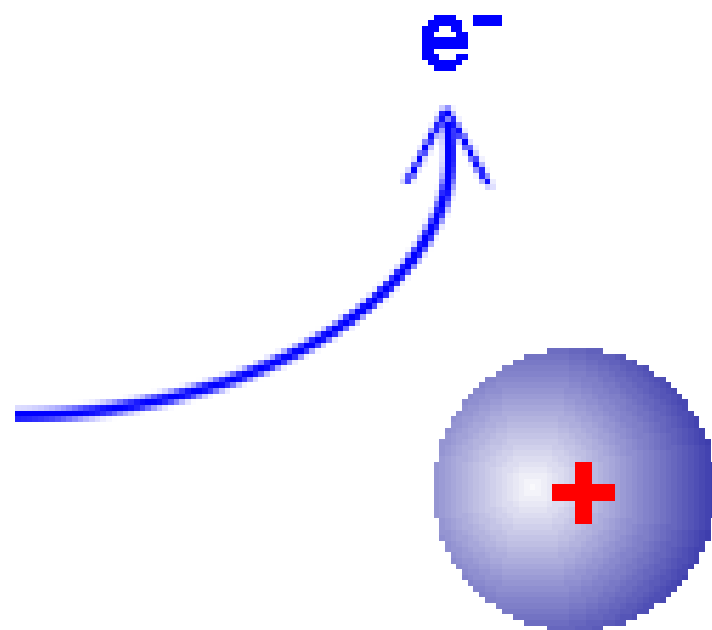
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Positive ions are **always smaller** than the original atom

- Because = lost electrons in outer energy level



Na  
186 pm



Na<sup>+</sup>  
97 pm

## 4. Ionic Radii

---

Negative ions are **always larger** than the original atom

- Because = more electrons with the same nuclear charge holding the atom together

## 4. Ionic Radii

---

- As you travel down a group (↓): atomic radii **increase** with both cations and anions
- Because: *radius is getting larger because of more orbitals*

## 4. Ionic Radii

---

As you travel across a period →:  
ionic radii **decrease** in size

- Because: *radius is getting smaller because of increased positive charge of nucleus*

# Your Turn:

---

Put these elements in order of decreasing ionic radius

- C N Li F O

- What is the trend?

- Answer: Li > C > N > O > F

# 5. Electronegativity

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**Electronegativity:** the tendency for an atom to attract electrons to itself when it is chemically combined with another element

- Expressed on the Pauling Electronegativity Scale
- Noble gases do not have electronegativities because they do not participate in many reactions

# 5. Electronegativity

---

As you go down a group (↓): decrease

- **Because:** *pull by the nucleus is not as strong due to increased layers of orbitals*
- Transition metal electronegativities and other properties are not as regular



# 5. Electronegativity

---

As you travel across a period →:  
**increase**

- **Because:** *radii are smaller due to stronger pull by nucleus*

# Periodic Table of Electronegativities

1	2												13	14	15	16	17
H 2.1	Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	
Cs 0.8	Ba 0.9	La* 1.1	Hf 1.3	Ta 1.5	W 2.4	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	
Fr 0.7	Ra 0.9	Ac† 1.1	* Lanthanides: 1.1–1.3 † Actinides: 1.3–1.5														

# Your Turn:

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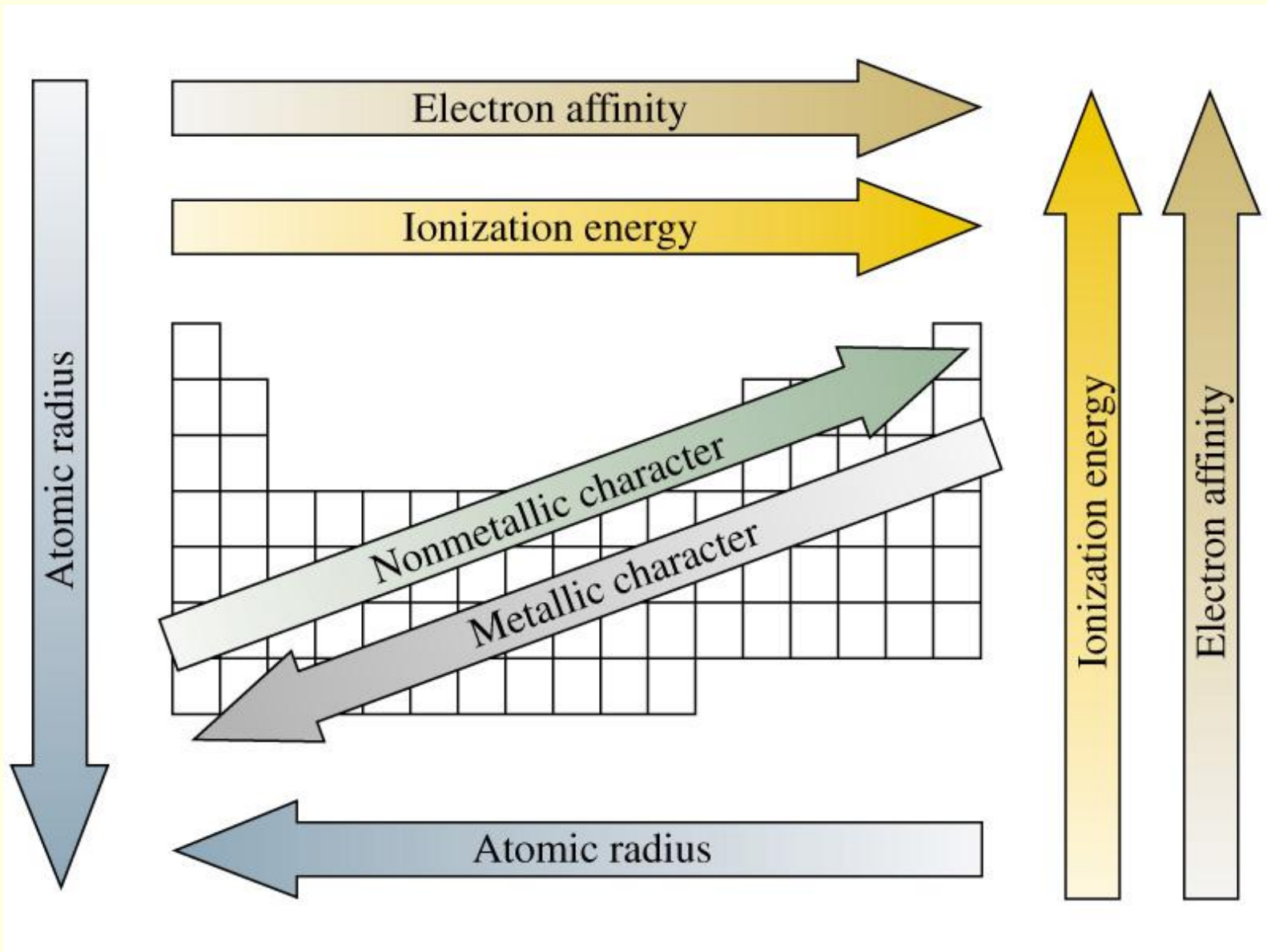
Put these elements in order of increasing electronegativity

- C N Li F O

- What is the trend?

- Answer: Li > C > N > O > F

# Summary of Periodic Trends



Increasing ionization energy  
Decreasing atomic radius  
Increasing nonmetallic character and electronegativity  
Decreasing metallic character

