Unit 2: The Periodic Table (chapter 5)

The Periodic Law:

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

Dmitri Mendeleev (1834-1907)

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- First to notice the element's periodic repetition of properties.

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- Arranged element in order of increasing atomic mass (not atomic number)

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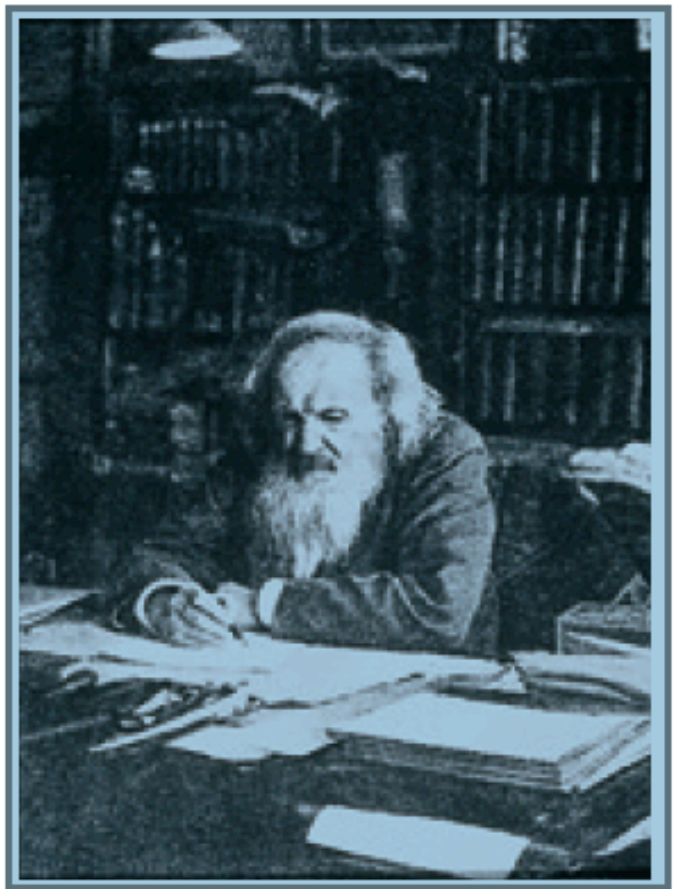
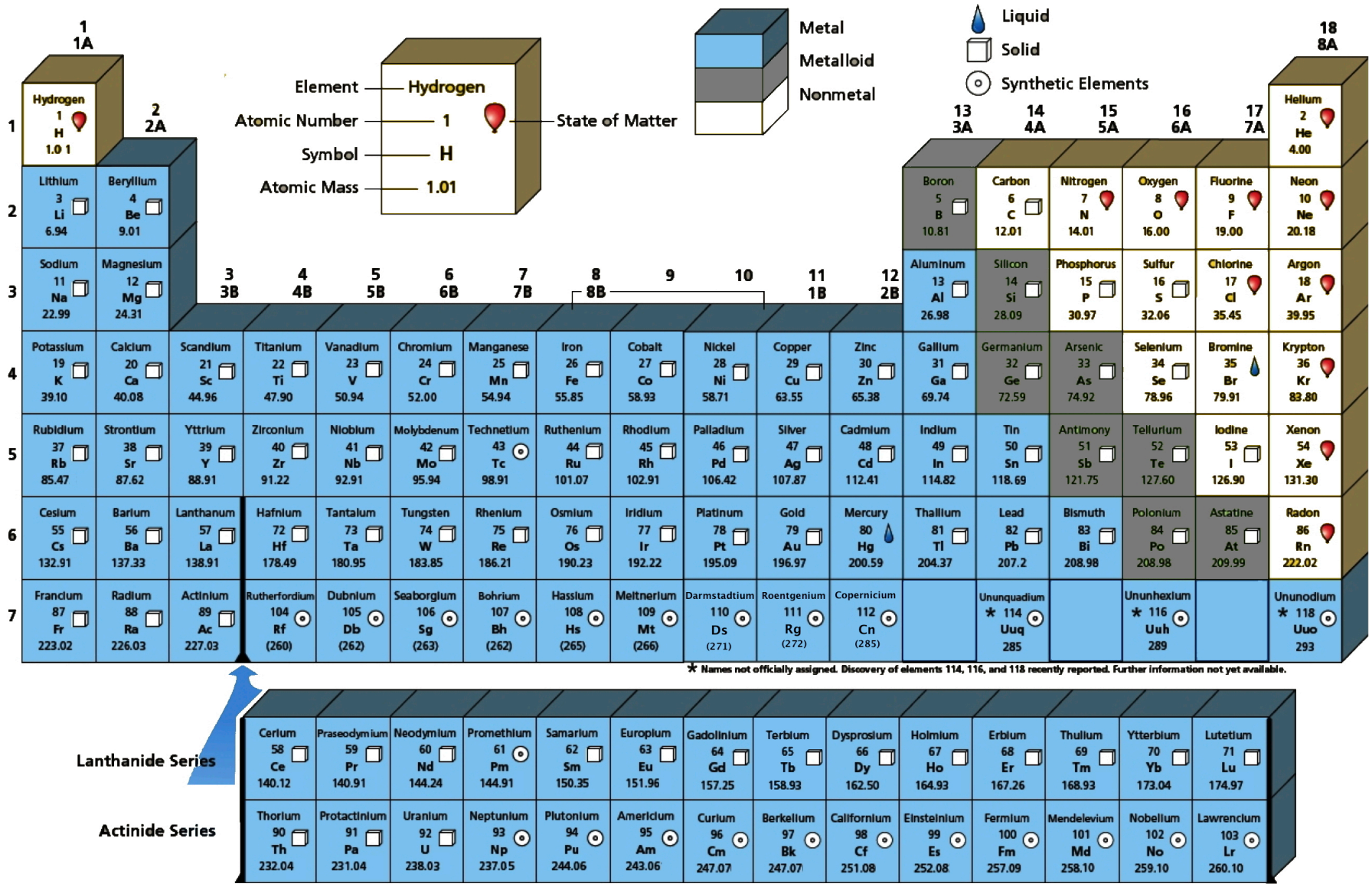
- Designed the first periodic table (1869)
- Arranged element in order of increasing atomic mass (not atomic number)
- Blank spaces we used for yet discovered elements




ПЕРИОДИЧЕСКАЯ СИСТЕМА ЭЛЕМЕНТОВ
Д. И. МЕНДЕЛЕЕВА
0 I II III IV V VI VII VIII
1 H
2 He Li Be B C N O F
3 Ne Na Mg Al Si P S Cl
4 Ar K Ca Sc Ti V Cr Mn Fe Co N
5 Cu Zn Ga Ge As Se Br
Ru Rh
Rb Sr Y Zr Nb Mo
Sn Sb Te J

Today's Modern Periodic Table (see yours!)



Wall Poster:

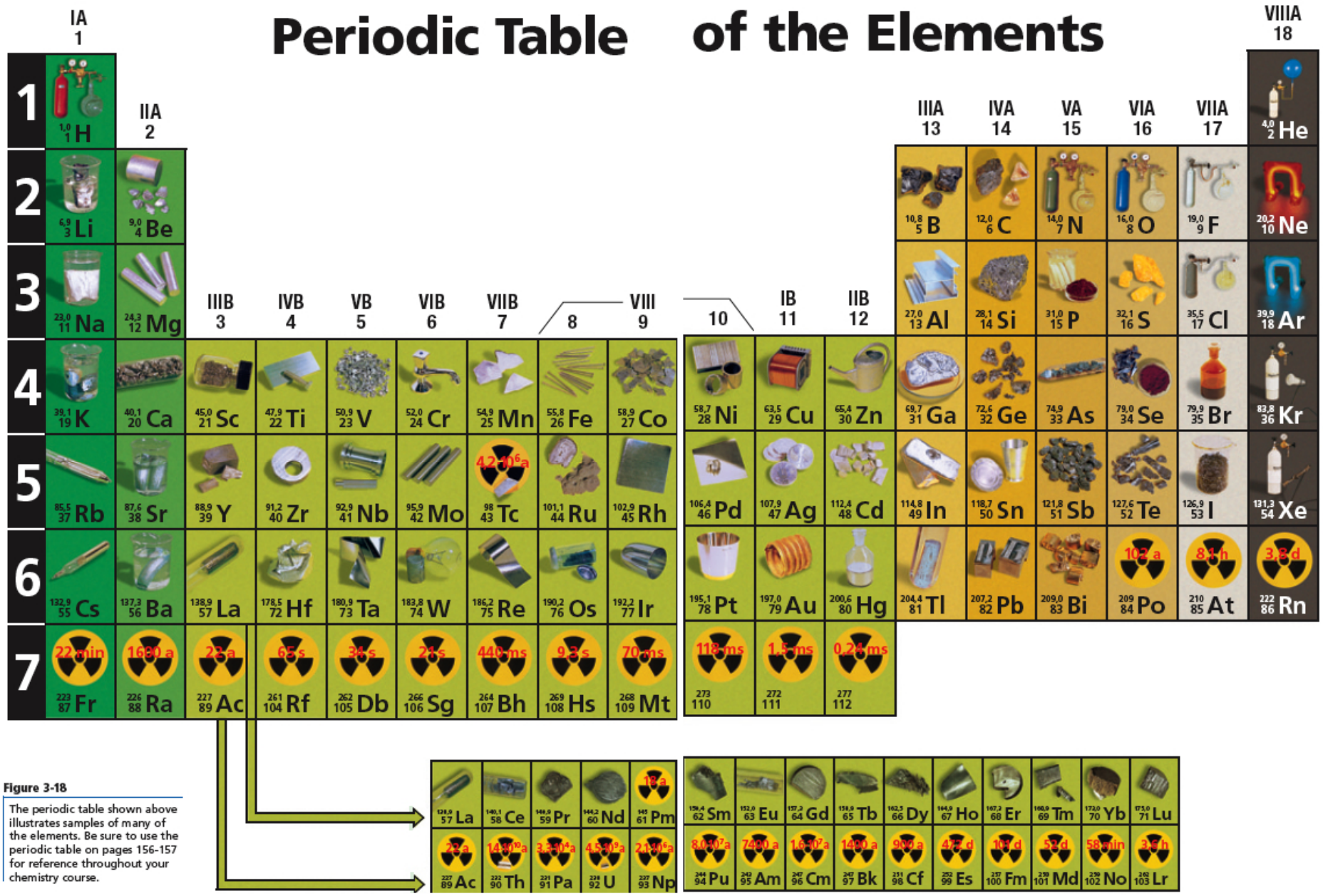


Figure 3-18

The periodic table shown above illustrates samples of many of the elements. Be sure to use the periodic table on pages 156-157 for reference throughout your chemistry course.

See Handout,
The Divided Periodic Table

The Divided Periodic Table

H																	
																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt									

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

Periods:

Horizontal rows, numbered 1-7.

Groups (or Families):
Vertical columns, numbered 1-18
(also 1A - 8 A)

Group	Family Name
1	Alkali metals (not H)
2	Alkaline earth metals
3-12	The transition metals
13	The Boron family
14	The Carbon family
15	The Nitrogen family
16	The Oxygen family
17	The Halogens

The Inner Transition Metals:

The Inner Transition Metals:

<u>Lanthanide</u> series (58-71)

<u>Actinide</u> series (90-103)

Semimetals (metalloids): Elements that have properties of both metals and nonmetals.

Metals:

Those elements that are a good conductors of heat or electricity and generally shiny; most are solid, ductile, and malleable.

Metals:
Those elements that are a good conductors of heat or electricity and generally shiny; most are solid, ductile, and malleable.

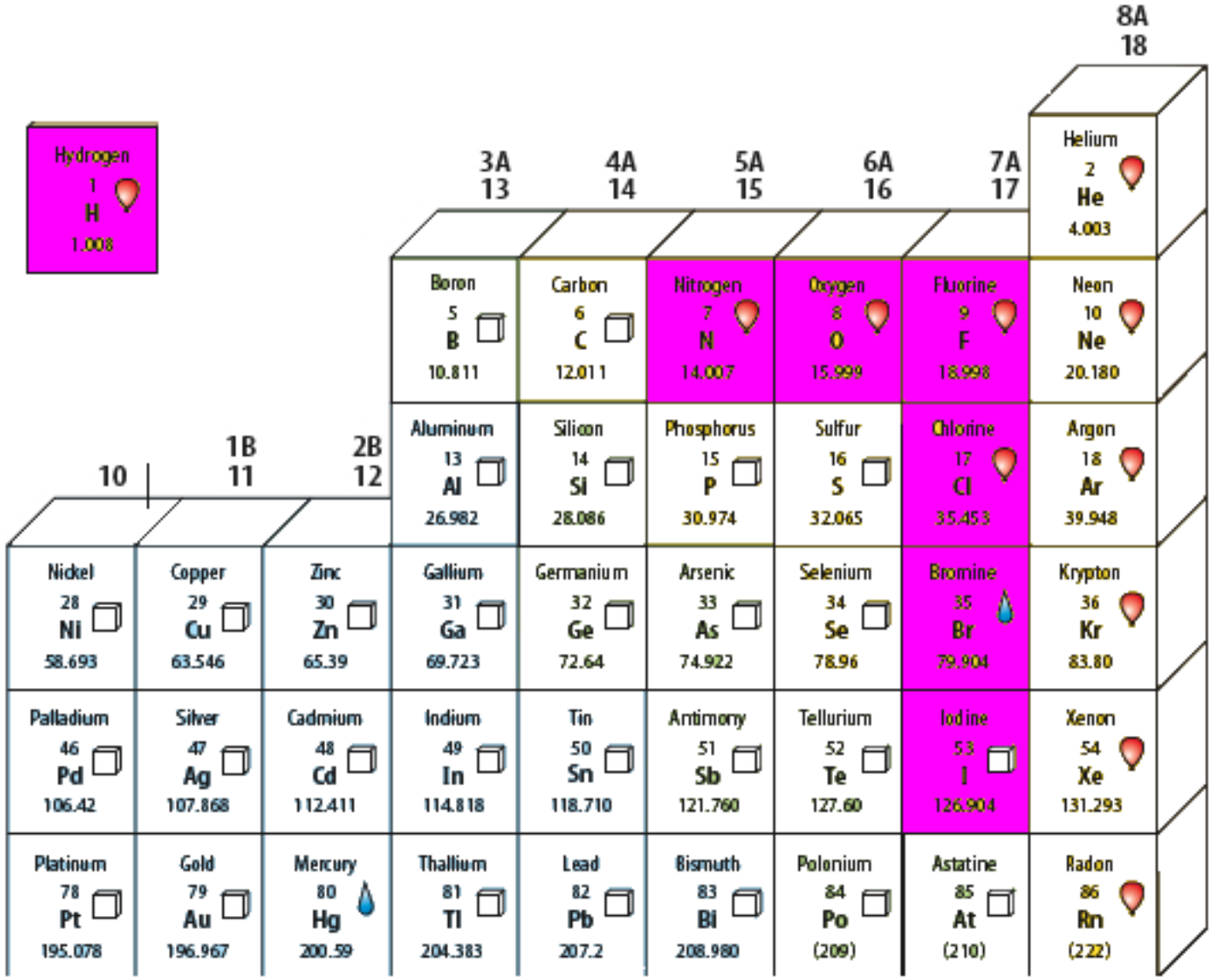
ductile: able to be drawn into wires

malleable: able to be molded, reshaped

Nonmetals:
Those elements that are generally gasses or dull, brittle solids and are poor conductors of heat and electricity.

<u>Diatomic Elements</u>: Elements that are found in nature as pairs of atoms; two identical atoms bonded together.

The Super Seven: H_2 , N_2 , O_2 , F_2 , Cl_2, Br_2 , and I_2



Phases (states):

- Liquids: Bromine and mercury
- Gases: H_2, N_2, O_2, F_2 , Cl_2, and all the noble gases.
- Solids: All other elements

Electron configurations

The Periodic Table can be broken into s, p, d, and f blocks, corresponding directly with the predictions made by quantum mechanics.

See back of handout: the divided periodic table!

An element's location on the Periodic Table indicates its electron configuration.

(in-class practice...)

Valence Electrons (p152)

- Responsible for an atom's chemical properties.
- Valence electrons are lost, gained, or shared to obtain the electron configuration of a noble gas.

- Valance electrons are only found in the outermost energy level of an atom... therefore, only belong to the outermost _s_ and _p_ sublevels.

Making the maximum number of valence electrons any atom can have... 8 !

The group numbering 1A - 8A indicates the number of valence electrons.

Group 1A = 1 valence electron
Group 2A = 2 valence electrons
etc..

Note: the transition elements all have only 2 valence electrons!

Dots are used to indicate the number of valence electrons around an atom...

(in-class practice)

Valence Shell: The region of space occupied by an atom's valence electrons.

Core electrons are those interior to the valence electrons.

The Octet Rule:

Atoms tend to lose, gain, or share electrons to obtain a "stable octet."

(The configuration of a noble gas!)

Ionic Charge:

<u>Metals:</u>

<u>lose</u> their valence electrons and become <u>positive</u> ions ("cations").

Nonmetals:

gain electrons to complete their valence shell

Nonmetals:

gain electrons to complete their valence shell and become negative ions ("anions")

Ionic Charge Trend:

Family	Charge
Alkali metals	+1
Alkaline earth metals	+2
Boron	+3
Carbon (nonmetals)	-4
Nitrogen (nonmetals)	-3
Oxygen (nonmetals)	-2
Halogens	-1
Noble Gases	0

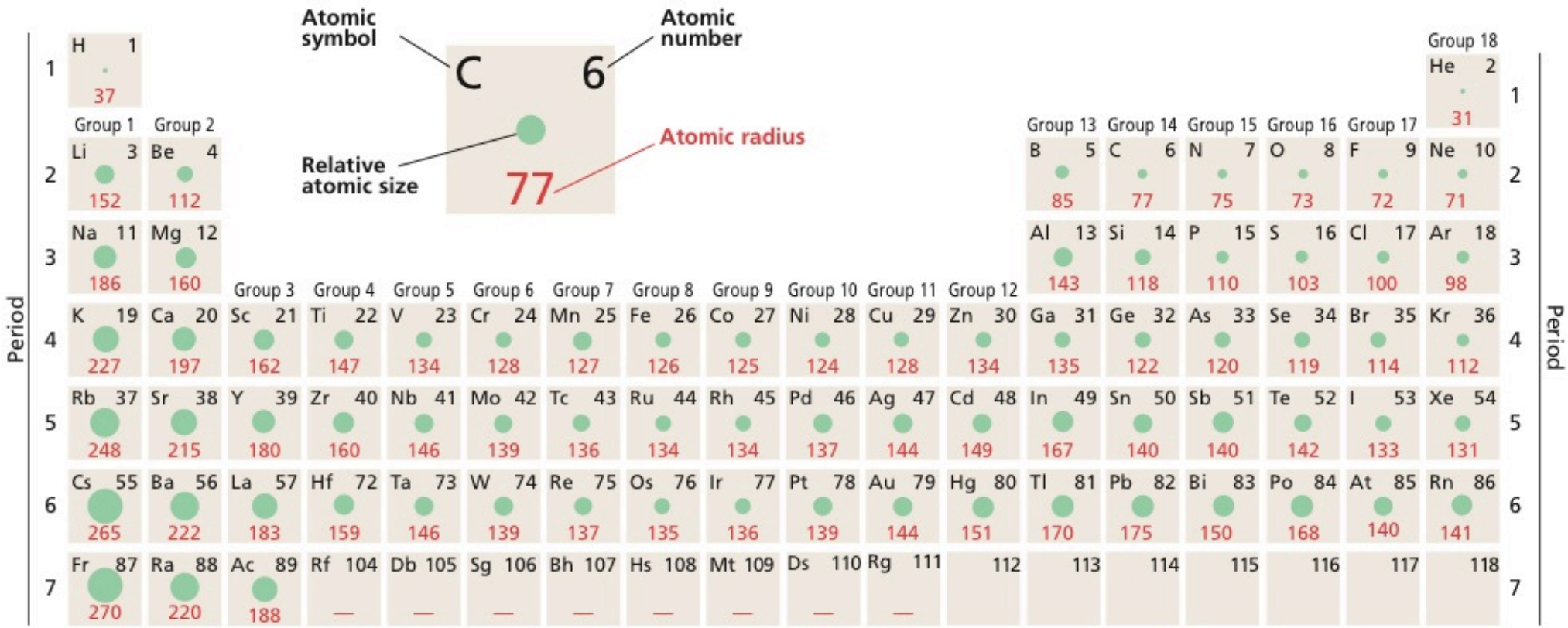
Periodic Properties (Section 5.3)

1. Atomic Radius:

The distance from the nucleus to the outermost electrons.

(See Figure 3.2, page 143)

Periodic Table of Atomic Radii (pm)



Note: Radius usually measured in picometers (10^{-12} m)

Atomic Radius Trend:

Decreases as you move across a period (due to the increase in nuclear charge)

Increases as you move down a family (electrons are being added to higher energy levels)

Ionic Radii Trend:

Decreases as electrons are lost (i.e., cations are smaller than their neutral atom).

Increases as electrons are added (i.e., anions are larger than their neutral atom).

2. Ionization Energy:

The energy required to remove the outermost electron from a gaseous atom.

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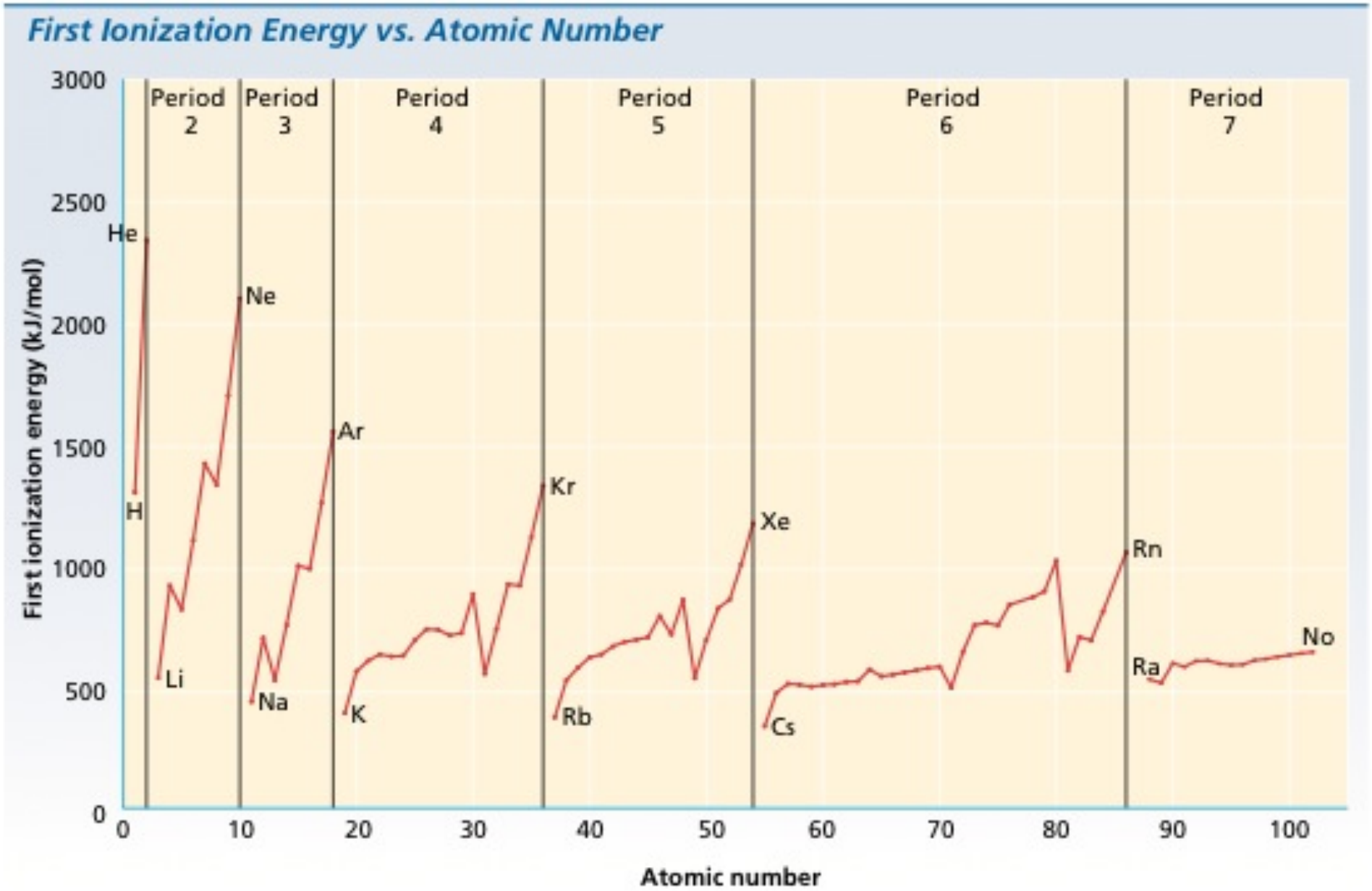
The energy required to remove the outermost electron from a *gaseous atom.

*a single, isolated atom.

2. <u>Ionization Energy</u>:

The energy required to remove the outermost electron from a gaseous atom. (Turns the atom into a positive ion.)

(Page 146)


First Ionization Energy vs. Atomic Number
Period 2
Period 3
Period 4
Period 5
Period 6
Period 7
First ionization energy (kJ/mol)
3000
2500
2000
1500
1000
500
0
He
H
Ne
Li
Ar
Na
K
Kr
Rb
Xe
Cs
Rn
Ra
No
0
10
20
30
40
50
60
70
80
90
100
Atomic number

Ionization energy trend:

Increases as you move across a period (as atoms get smaller, electrons are closer to the nucleus and harder to remove)

Decreases as you move down a family (as atoms get larger, electrons are farther from the nucleus and easier to remove)

Successive Ionization Energies:

(See figure 3.6, page 147)

TABLE 3 *Ionization Energies (in kJ/mol) for Elements of Periods 1–3*

	Period 1		Period 2							
	H	He	Li	Be	B	C	N	O	F	Ne
IE_1	1312	**2372**	520	900	801	1086	1402	1314	1681	2081
IE_2		5250	**7298**	1757	2427	2353	2856	3388	3374	3952
IE_3			11 815	**14 849**	3660	4621	4578	5300	6050	6122
IE_4				21 007	**25 026**	6223	7475	7469	8408	9370
IE_5					32 827	**37 830**	9445	10 990	11 023	12 178
			Period 3							
			Na	Mg	Al	Si	P	S	Cl	Ar
IE_1			496	738	578	787	1012	1000	1251	1521
IE_2			**4562**	1451	1817	1577	1903	2251	2297	2666
IE_3			6912	**7733**	2745	3232	2912	3361	3822	3931
IE_4			9544	10 540	**11 578**	4356	4957	4564	5158	5771
IE_5			13 353	13 628	14 831	**16 091**	6274	7013	6540	7238

Successive Ionization Energies:

An increase in ionization energy as more electrons are removed.

Key idea:

Valence electrons are removed relatively easily...

but there will be a huge jump in ionization energy when removing a <u>core</u> electron!

3. <u>Electronegativity</u>:

The ability of an atom to attract electrons in a chemical bond.

(See Figure 3.11, page 153)

Periodic Table of Electronegativities

Atomic number	Symbol	Electronegativity
6	C	2.5

Period	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1	1 H 2.1																	2 He —
2	3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0	10 Ne —
3	11 Na 0.9	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0	18 Ar —
4	19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.8	28 Ni 1.8	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8	36 Kr 3.0
5	37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5	54 Xe 2.6
6	55 Cs 0.7	56 Ba 0.9	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.8	83 Bi 1.9	84 Po 2.0	85 At 2.2	86 Rn 2.4
7	87 Fr 0.7	88 Ra 0.9	89 Ac 1.1	104 Rf —	105 Db —	106 Sg —	107 Bh —	108 Hs —	109 Mt —	110 Ds —	111 Rg —	112	113	114	115	116	117	118

Lanthanide series													
58 Ce 1.1	59 Pr 1.1	60 Nd 1.1	61 Pm 1.1	62 Sm 1.2	63 Eu 1.1	64 Gd 1.2	65 Tb 1.1	66 Dy 1.2	67 Ho 1.2	68 Er 1.2	69 Tm 1.3	70 Yb 1.1	71 Lu 1.3
90 Th 1.3	91 Pa 1.5	92 U 1.4	93 Np 1.4	94 Pu 1.3	95 Am 1.3	96 Cm 1.3	97 Bk 1.3	98 Cf 1.3	99 Es 1.3	100 Fm 1.3	101 Md 1.3	102 No 1.3	103 Lr —

Actinide series

Electronegativity Trend:

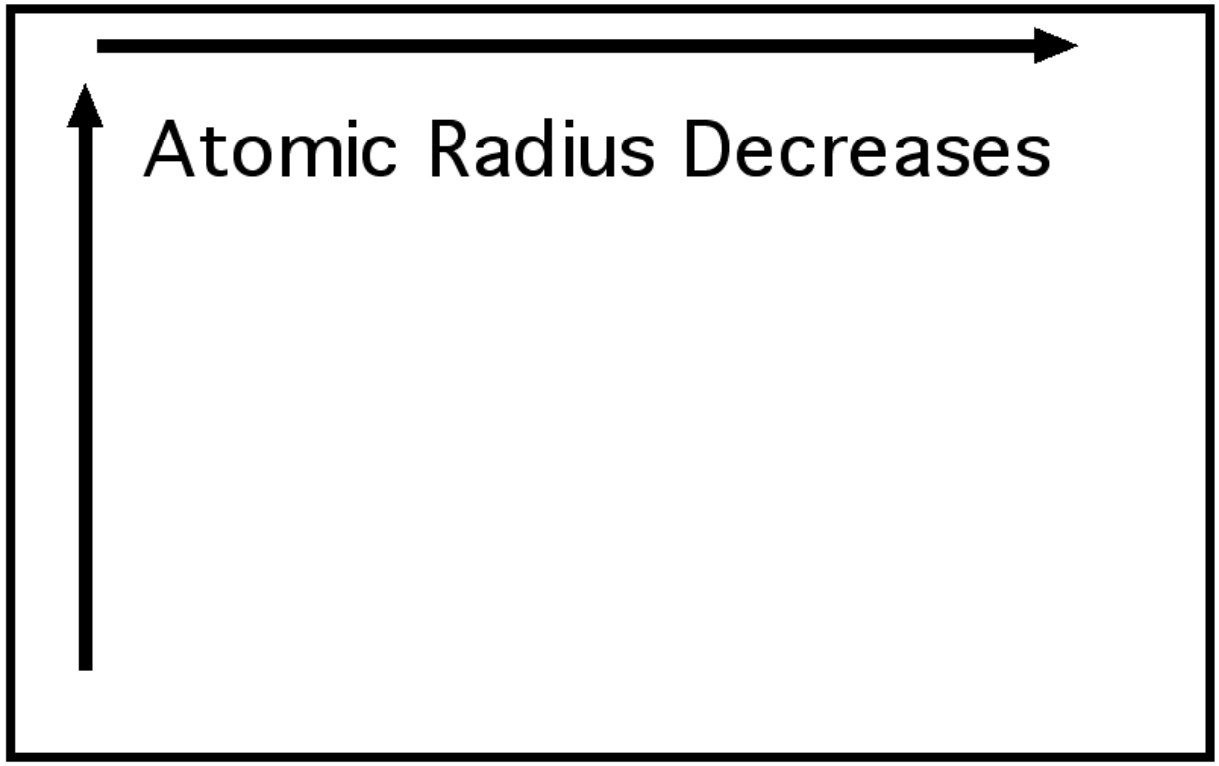
Increases as you move across a period

(as atoms get smaller, electrons are closer to the nucleus and more tightly held)

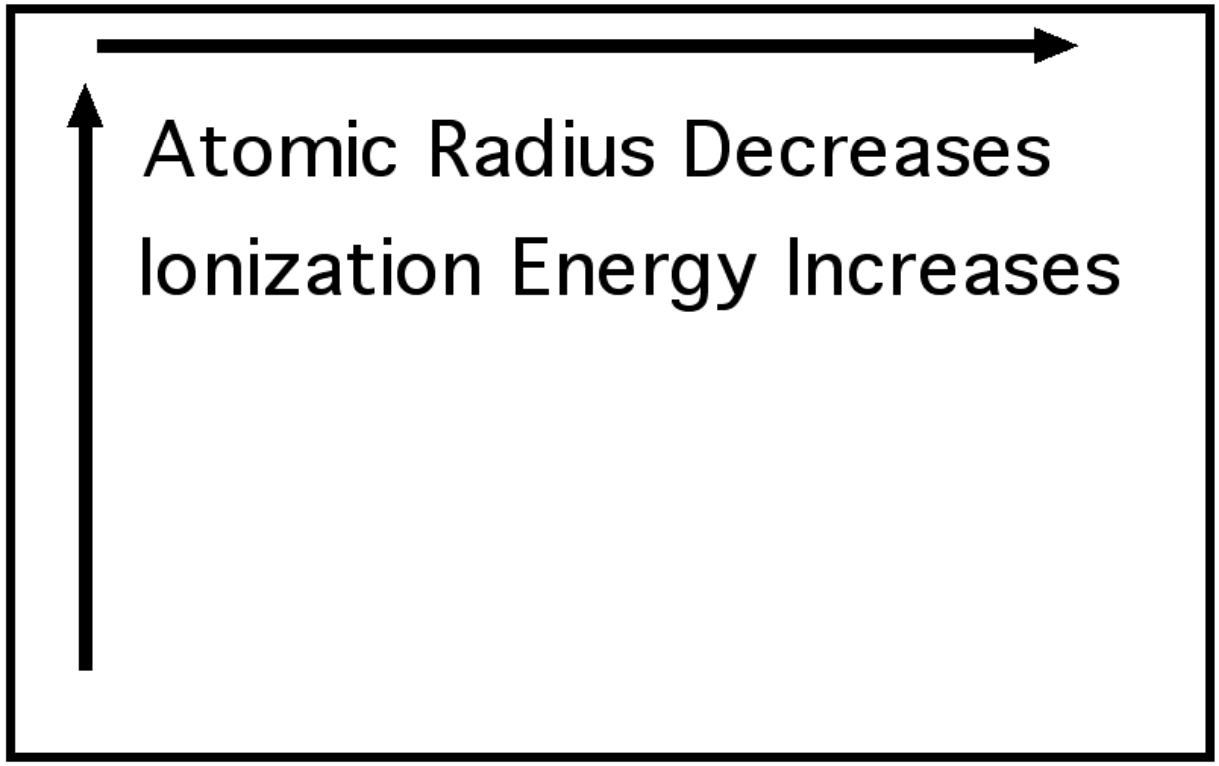
Decreases as you move down a family

(as atoms get larger, electrons are farther from the nucleus and more weakly held)

Periodic Trends (at-a-glance)



Periodic Trends (at-a-glance)



Periodic Trends (at-a-glance)

Atomic Radius Decreases

Ionization Energy Increases

Electronegativity Increases

Shielding effect:

The repulsive force exerted on valence electrons by core electrons.

(the more core electrons an atom has, the greater the shielding effect!)

- increases atomic radius
- lowers ionization energy
- lowers electronegativity