

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)

Dmitri Mendeleev (1834-1907)

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

Dmitri Mendeleev (1834-1907)

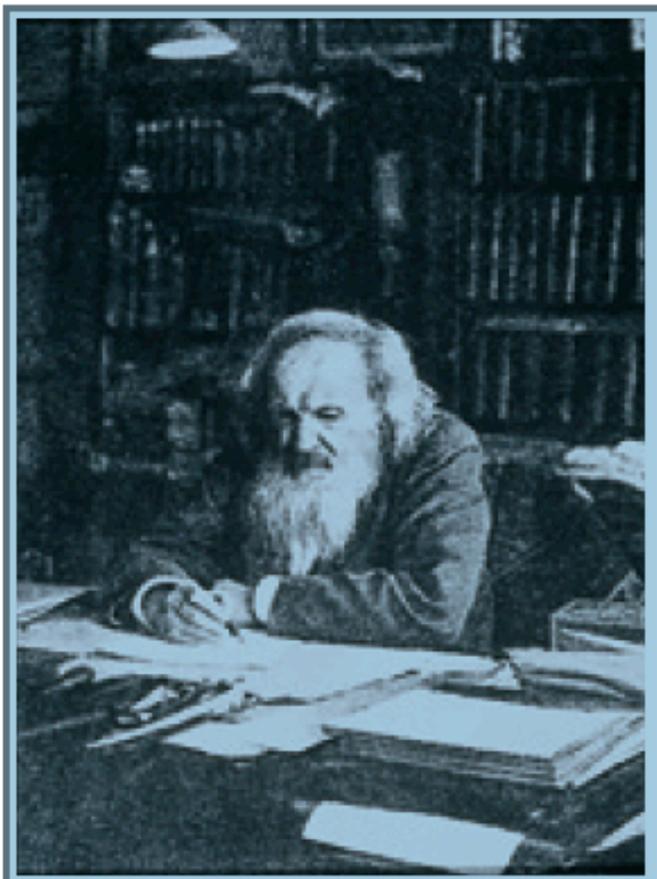
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- Arranged element in order of increasing atomic mass (not atomic number)

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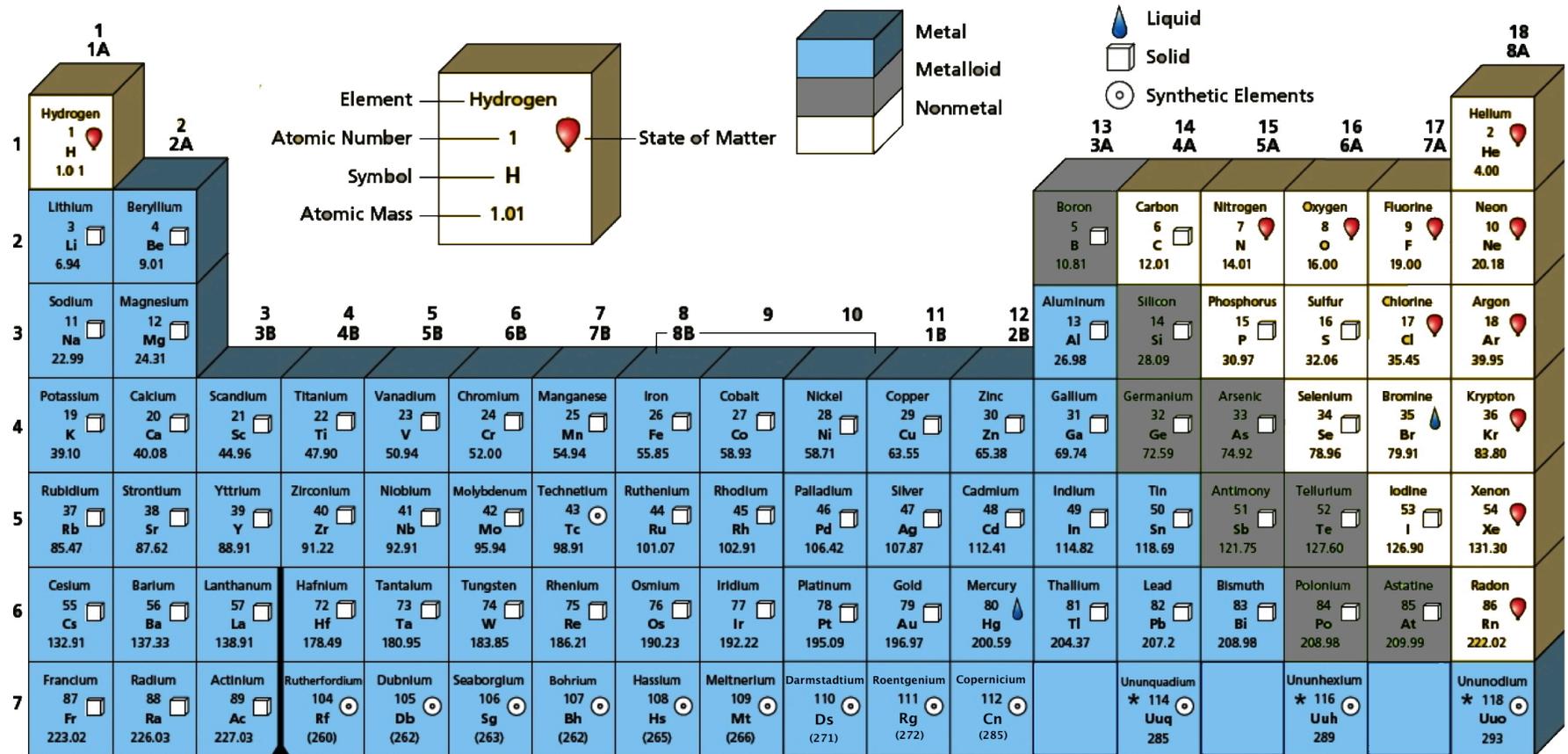
- First to notice the element's periodic repetition of properties.
- Designed the first periodic table (1869)
- Arranged element in order of increasing atomic mass (not atomic number)
- Blank spaces we used for yet discovered elements



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 Ni
5		Cu	Zn	Ga	Ge	As	Se	Br	
	Rh	Sr	Y	Zr	Nb	Mo			Ru Rh Pd
				Sb	Te	J			

Today's Modern Periodic Table (see yours!)



* Names not officially assigned. Discovery of elements 114, 116, and 118 recently reported. Further information not yet available.

Lanthanide Series

Actinide Series

Cerium 58 Ce 140.12	Praseodymium 59 Pr 140.91	Neodymium 60 Nd 144.24	Promethium 61 Pm 144.91	Samarium 62 Sm 150.35	Europium 63 Eu 151.96	Gadolinium 64 Gd 157.25	Terbium 65 Tb 158.93	Dysprosium 66 Dy 162.50	Holmium 67 Ho 164.93	Erbium 68 Er 167.26	Thulium 69 Tm 168.93	Ytterbium 70 Yb 173.04	Lutetium 71 Lu 174.97
Thorium 90 Th 232.04	Protactinium 91 Pa 231.04	Uranium 92 U 238.03	Neptunium 93 Np 237.05	Plutonium 94 Pu 244.06	Americium 95 Am 243.06	Curium 96 Cm 247.07	Berkelium 97 Bk 247.07	Californium 98 Cf 251.08	Einsteinium 99 Es 252.08	Fermium 100 Fm 257.09	Mendelevium 101 Md 258.10	Nobelium 102 No 259.10	Lawrencium 103 Lr 260.10

Wall Poster:

Periodic Table of the Elements

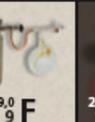
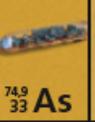
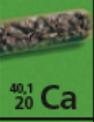
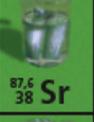
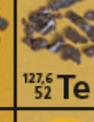
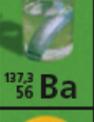
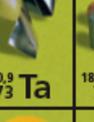
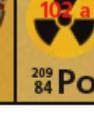
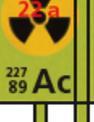
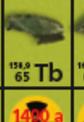
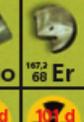
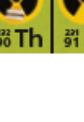
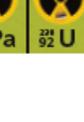
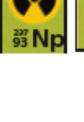
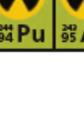
IA 1												IIIA 13					IVA 14	VA 15	VIA 16	VIIA 17	VIIIA 18
1	 1.0 1 H											 10.8 5 B	 12.0 6 C	 14.0 7 N	 16.0 8 O	 19.0 9 F	 4.0 2 He				
2	 6.9 3 Li	 9.0 4 Be											 27.0 13 Al	 28.1 14 Si	 31.0 15 P	 32.1 16 S	 35.5 17 Cl	 39.9 18 Ar			
3	 23.0 11 Na	 24.3 12 Mg	IIIB 3	IVB 4	VB 5	VIB 6	VII B 7	VIII 8 9		IB 11	IIB 12	 69.7 31 Ga	 72.6 32 Ge	 74.9 33 As	 79.0 34 Se	 79.9 35 Br	 83.8 36 Kr				
4	 39.1 19 K	 40.1 20 Ca	 45.0 21 Sc	 47.9 22 Ti	 50.9 23 V	 52.0 24 Cr	 54.9 25 Mn	 55.8 26 Fe	 58.9 27 Co	 58.7 28 Ni	 63.5 29 Cu	 65.4 30 Zn	 69.7 31 Ga	 72.6 32 Ge	 74.9 33 As	 79.0 34 Se	 79.9 35 Br	 83.8 36 Kr			
5	 85.5 37 Rb	 87.6 38 Sr	 88.9 39 Y	 91.2 40 Zr	 92.9 41 Nb	 95.9 42 Mo	 98 43 Tc	 101.1 44 Ru	 102.9 45 Rh	 106.4 46 Pd	 107.9 47 Ag	 112.4 48 Cd	 114.8 49 In	 118.7 50 Sn	 121.8 51 Sb	 127.6 52 Te	 126.9 53 I	 131.3 54 Xe			
6	 132.9 55 Cs	 137.3 56 Ba	 138.9 57 La	 178.5 72 Hf	 180.9 73 Ta	 183.8 74 W	 186.2 75 Re	 190.2 76 Os	 192.2 77 Ir	 195.1 78 Pt	 197.0 79 Au	 200.6 80 Hg	 204.4 81 Tl	 207.2 82 Pb	 209.0 83 Bi	 209 84 Po	 210 85 At	 222 86 Rn			
7	 223 87 Fr	 226 88 Ra	 227 89 Ac	 261 104 Rf	 262 105 Db	 266 106 Sg	 264 107 Bh	 269 108 Hs	 268 109 Mt	 273 110	 272 111	 277 112									

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.

 138.9 57 La	 140.1 58 Ce	 140.9 59 Pr	 144.2 60 Nd	 145 61 Pm	 150.4 62 Sm	 152.0 63 Eu	 157.3 64 Gd	 158.9 65 Tb	 162.5 66 Dy	 164.9 67 Ho	 167.3 68 Er	 168.9 69 Tm	 173.0 70 Yb	 175.0 71 Lu
 227 89 Ac	 232 90 Th	 231 91 Pa	 238 92 U	 237 93 Np	 244 94 Pu	 243 95 Am	 247 96 Cm	 247 97 Bk	 251 98 Cf	 252 99 Es	 257 100 Fm	 257 101 Md	 259 102 No	 262 103 Lr

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:

Lanthanide series (58-71)

Actinide 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.

Diatomic Elements: 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

			3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
Hydrogen 1 H 1.008							Helium 2 He 4.003	
			Boron 5 B 10.811	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180
			Aluminum 13 Al 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 S 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948
Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.39	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.80
Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	Iodine 53 I 126.904	Xenon 54 Xe 131.293
Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 Tl 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)

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:

Metals:

lose their valence electrons and become positive 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

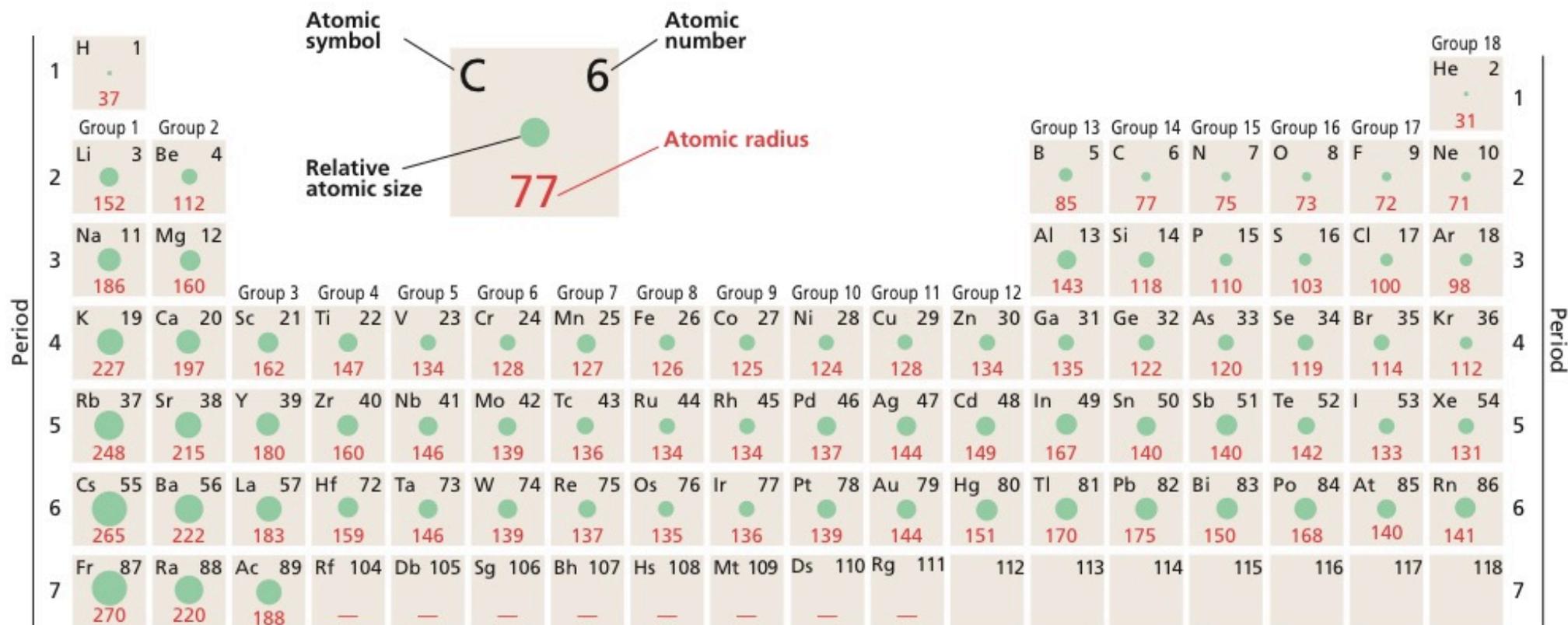
Periodic Properties (Section 5.3)

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.

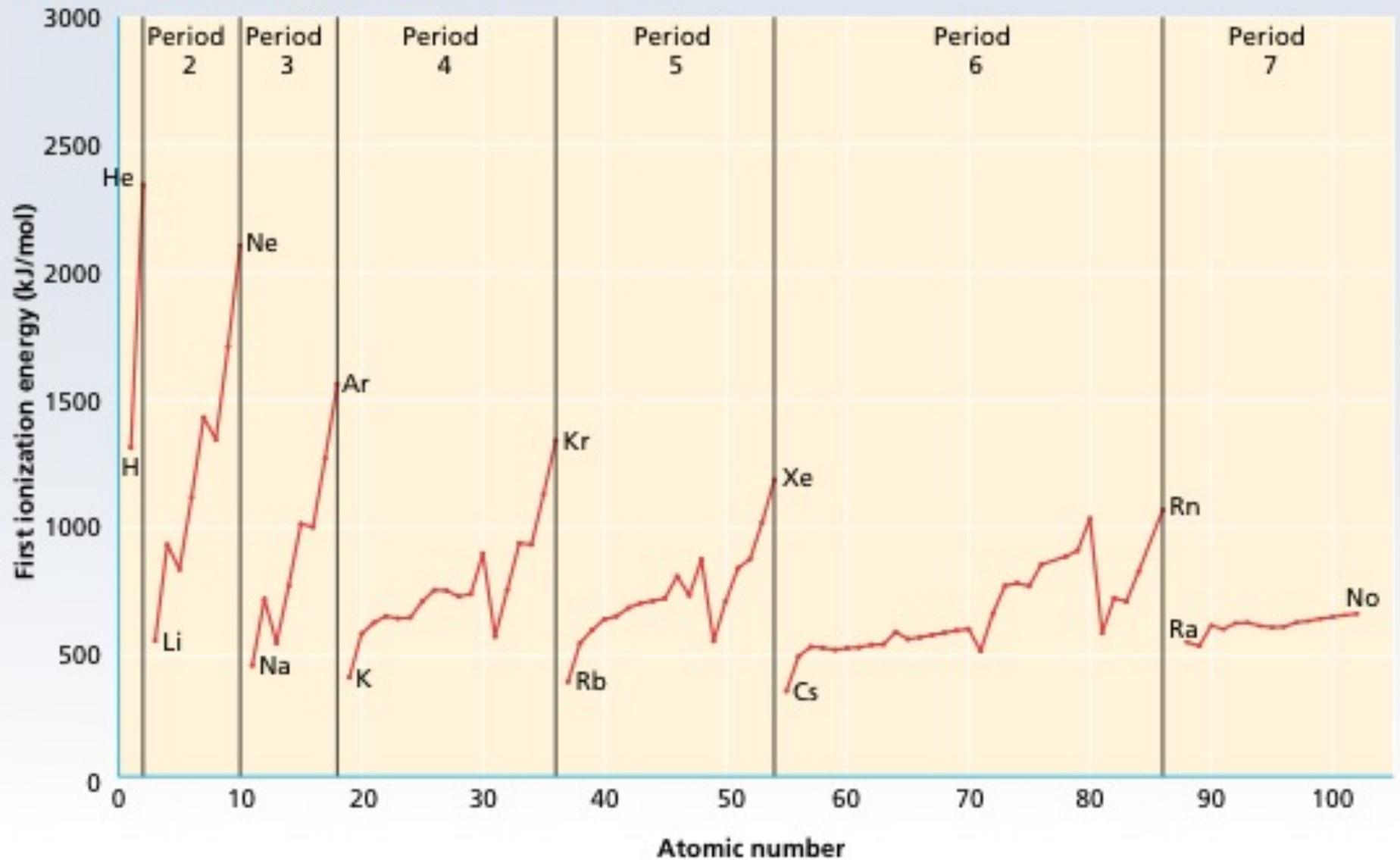
*a single, isolated atom.

2. Ionization Energy:

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



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 core electron!

3. Electronegativity:

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

(See Figure 3.11, page 153)

Periodic Table of Electronegativities

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

Atomic number: 6

Symbol: C

Electronegativity: 2.5

Lanthanide series

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
1.1	1.1	1.1	1.1	1.2	1.1	1.2	1.1	1.2	1.2	1.2	1.3	1.1	1.3
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
1.3	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	—

Actinide series

Electronegativity Trend:

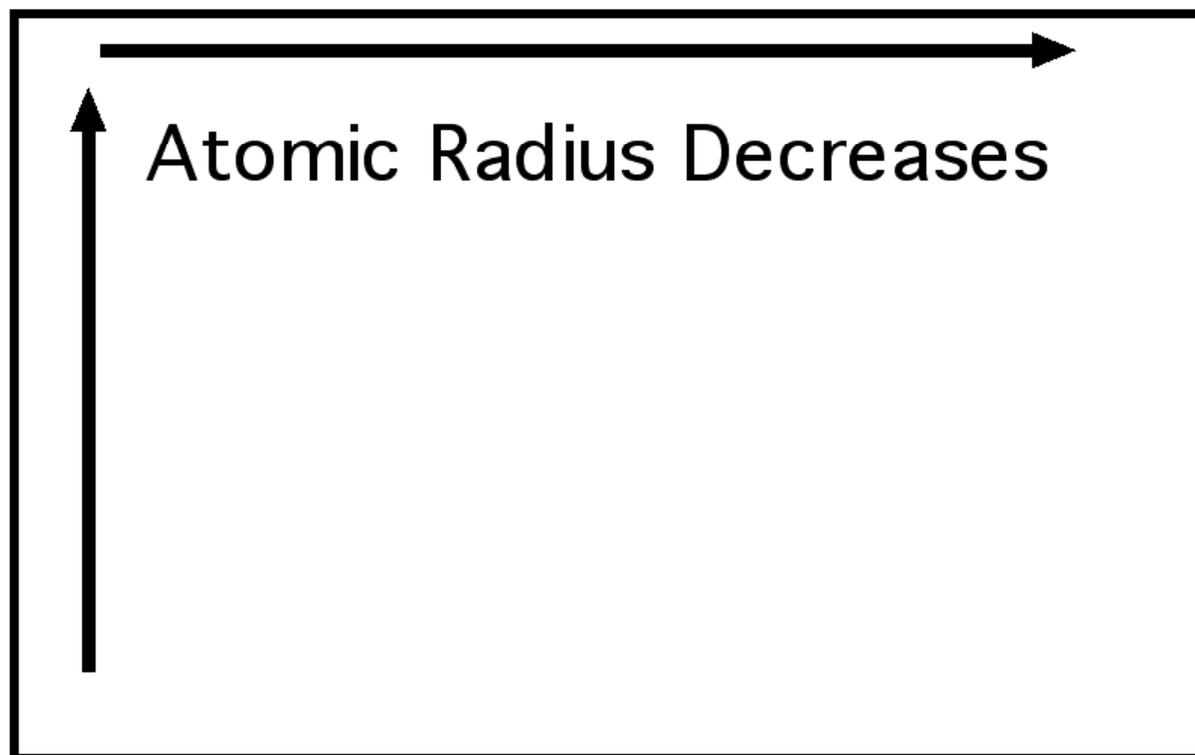
Increases as you move across a period

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

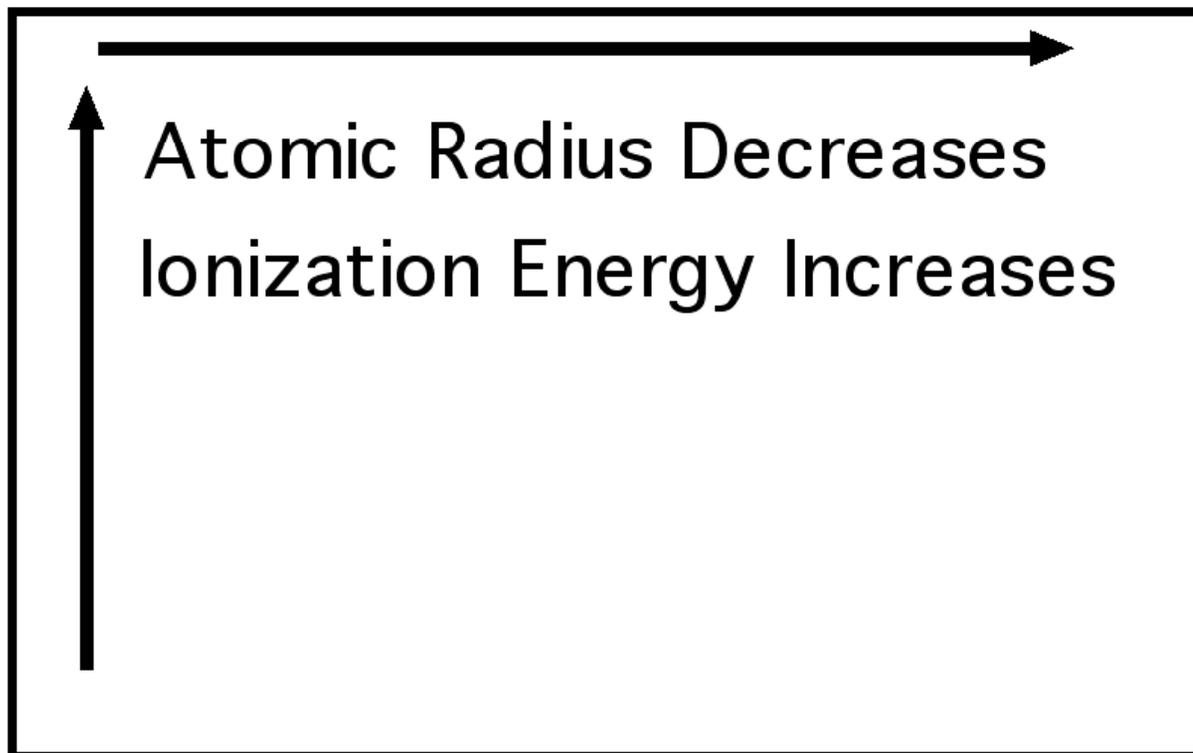
Decreases as you move down a family

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

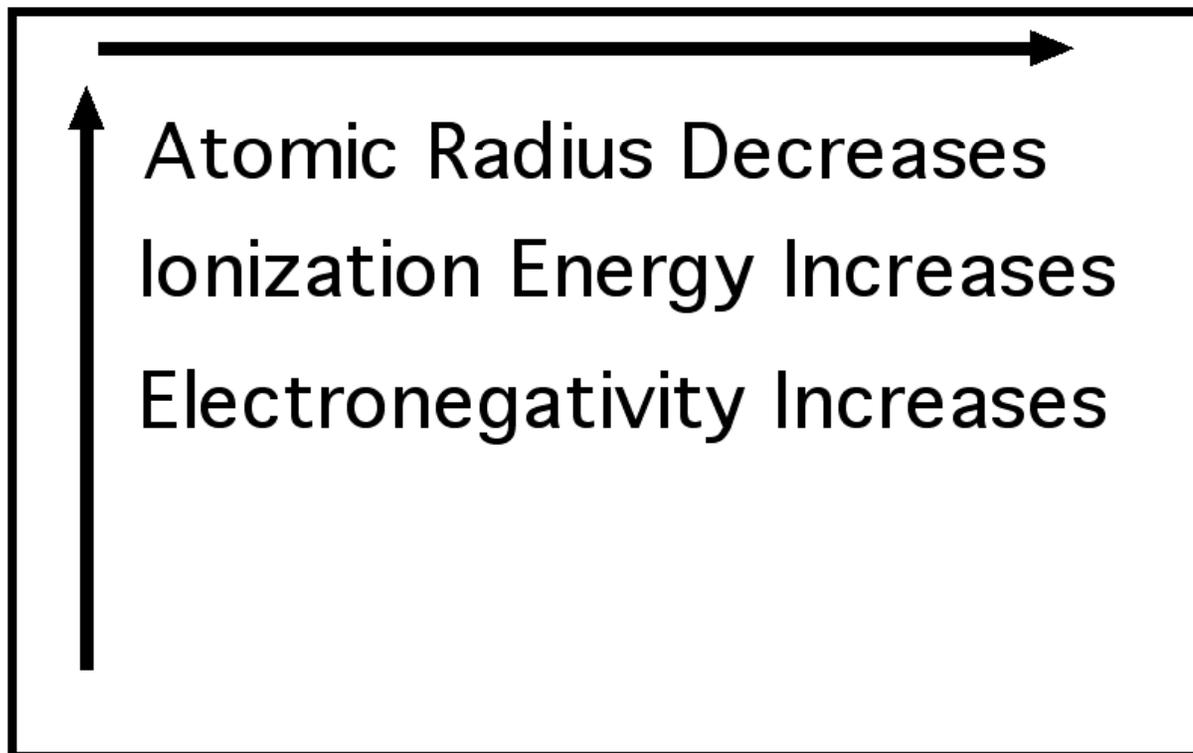
Periodic Trends (at-a-glance)



Periodic Trends (at-a-glance)



Periodic Trends (at-a-glance)



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