

The Periodic Table

Objectives

- ❖ **Describe how Mendeleev arranged the elements in the periodic table**
- ❖ **Explain how the predictions Mendeleev made and the discovery on new elements demonstrated the usefulness of his periodic table**

History on the Organization of Elements

■ Antoine Lavoiser

- organized known elements (very few) into metals, non metals, gases, and earths

■ Dmitri Mendeleev

- organization based on a popular card game solitaire
- each card had the elements name, mass, and properties
- lined up the cards in order of increasing mass, found a pattern
 - elements with similar properties were in the same column

Mendeleev

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

■ Predictions

- could not make a complete table, only had 63 elements leaving many spaces between elements
- used properties of other elements to predict undiscovered elements properties

Mendeleev

■ Evidence

- named some of the missing elements, and predicted some of their properties
- as elements were found scientists were able to verify properties and even explain chemical behaviors of elements in groups

Periodic Law

- Medeleev's periodic table was completed before the discovery of protons.
- by looking at certain trends, among the elements a new organization was created
- **Periodic Law**
 - pattern of repeating properties displayed by elements in the periodic table

SO...the periodic table is now arranged by atomic number instead of atomic mass

Objectives

- ❖ Describe the arrangement of elements in the modern periodic table
- ❖ Understand the trends that established the modern periodic table
- ❖ Locate periods and groups in the period table

Valence Electrons

■ Definition

- an electron that is in the highest occupied energy level of an atom
- determine the properties of elements



Valence Electrons Cont.

Remember your shells: 2e-, 8e-, 8e-, 18e-, 18e-, 32e-

ex. Sodium

Neon

** Group number or group number – 10**

Lewis Dot Structures

- electron dot diagram, where each dot represents a valence electron

ex.

- Practice Problems

Br

K

Be

Al

Ions

■ Definition

- an atom or group of atoms that has a positive or negative charge

ex. Cl⁻, Ca²⁺

■ Formation of Ions

- atom gains or loses electrons (protons = electrons)

- atom is no longer neutral

- become a cation or an anion

Ions Cont.

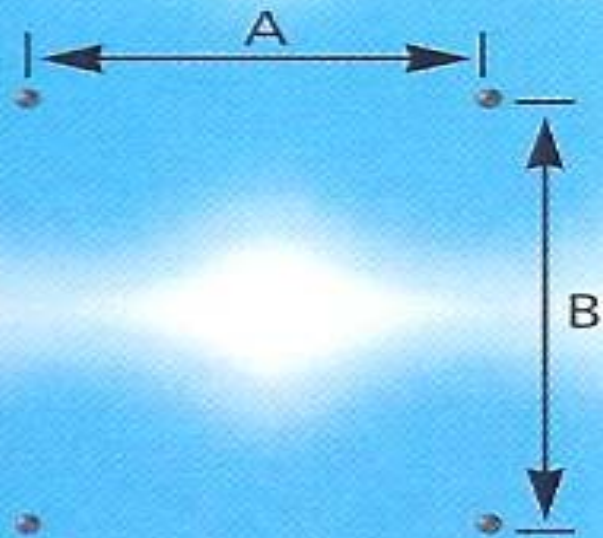
- cation (+): lost electrons
 - now name of atom + *ion* : sodium *ion*
- anion (-): gained electrons
 - now ends in *ide*: Chloride

Organizing the Elements Cont.

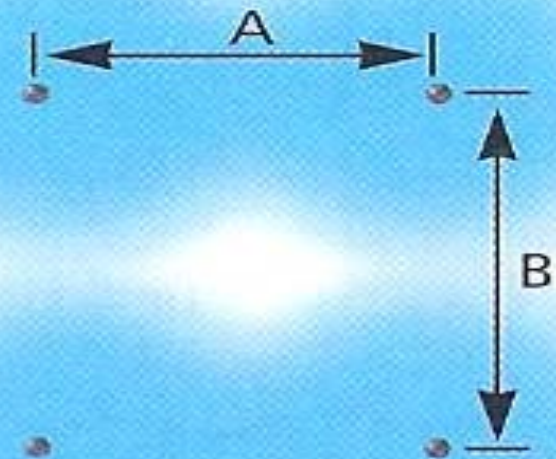
■ Atomic Radii:

- half the distance between the nuclei of the same atoms bonded together

I_2

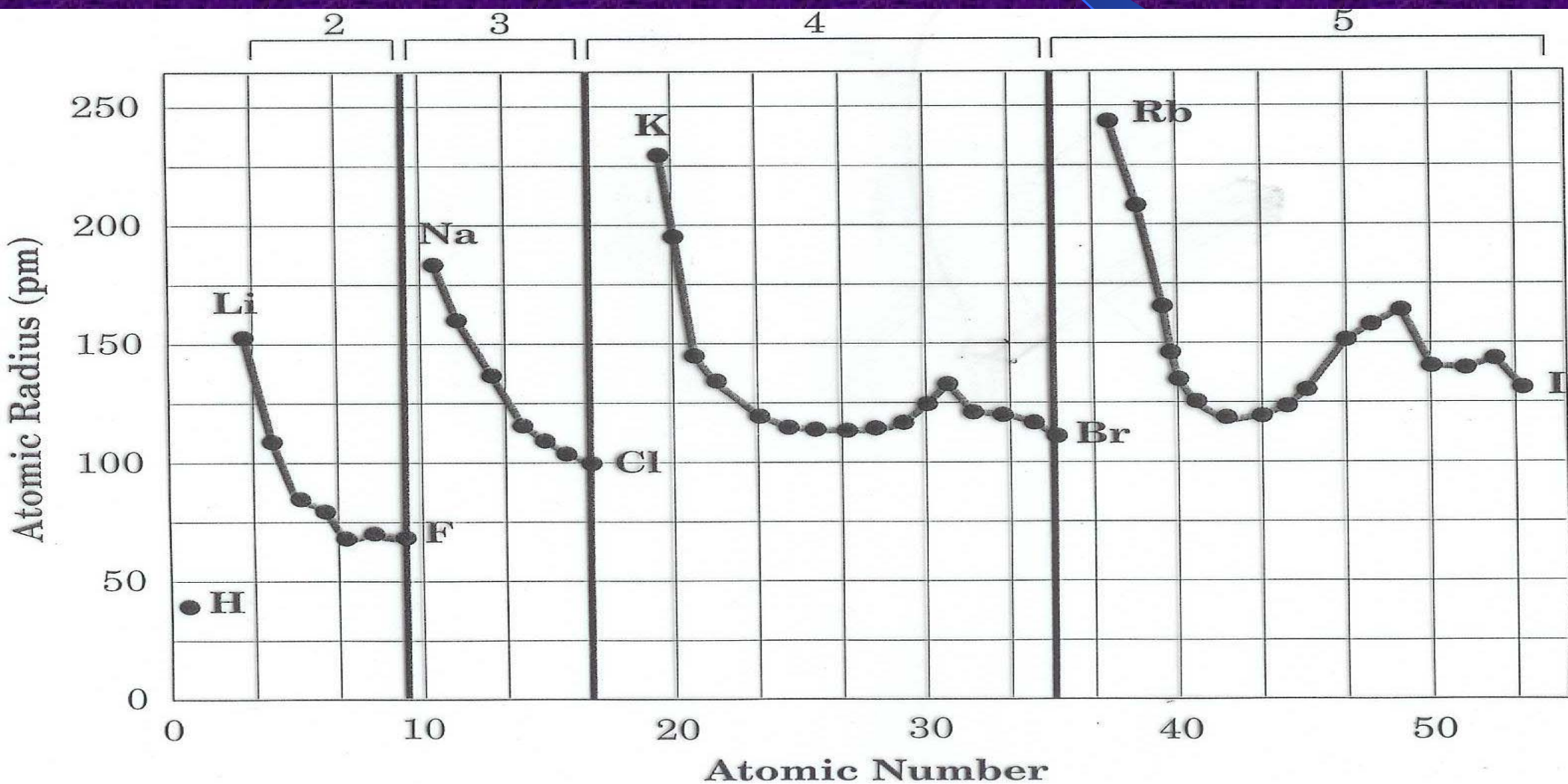


Br_2

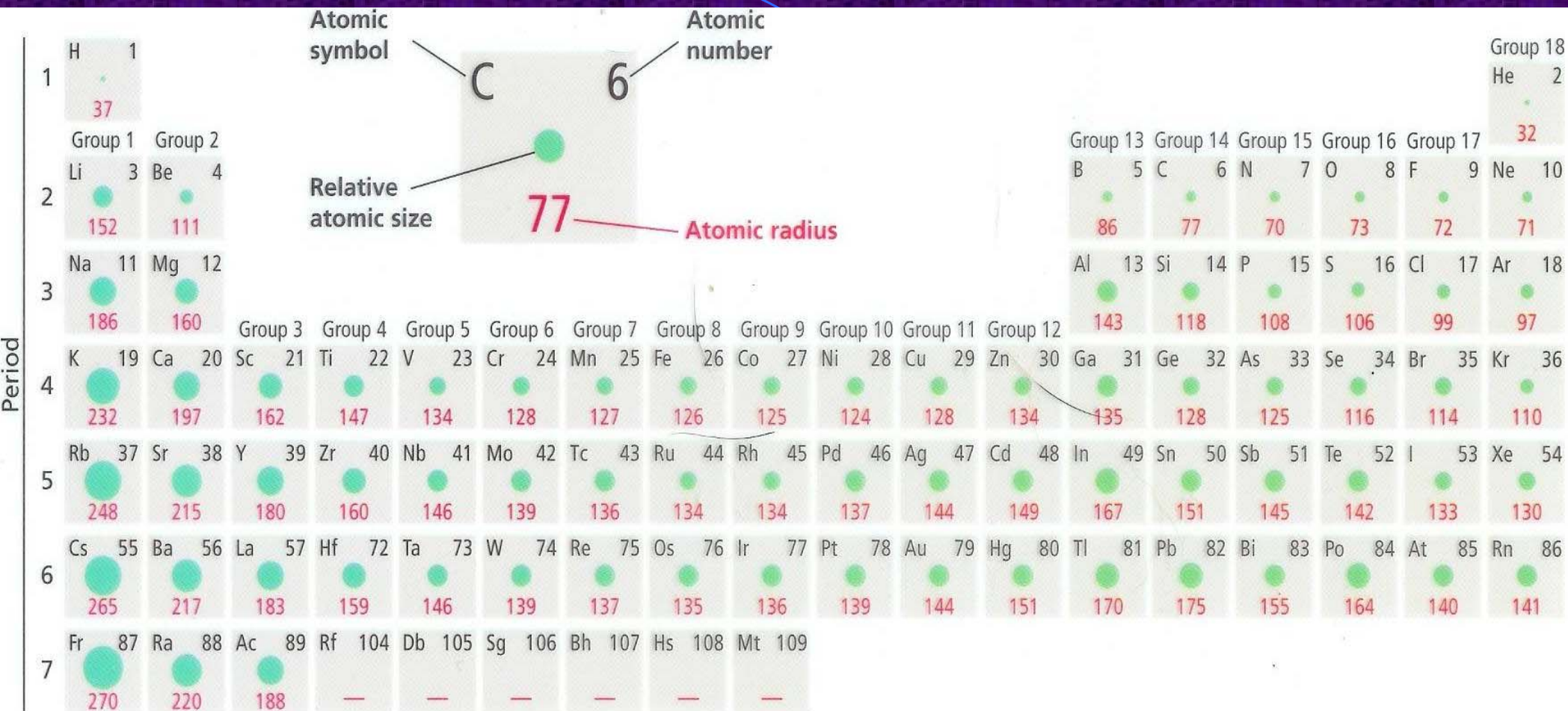


Trends of the Atomic Radii

- at certain intervals, atomic radii is dramatically greater than that of the previous element



Trends of the Atomic Radii



Lanthanide series

Ce 58 182	Pr 59 182	Nd 60 181	Pm 61 183	Sm 62 180	Eu 63 208	Gd 64 180	Tb 65 177	Dy 66 178	Ho 67 176	Er 68 176	Tm 69 176	Yb 70 —	Lu 71 174
Th 90 179	Pa 91 163	U 92 156	Np 93 155	Pu 94 159	Am 95 173	Cm 96 174	Bk 97 —	Cf 98 186	Es 99 186	Fm 100 —	Md 101 —	No 102 —	Lr 103 —

Organizing the Elements Cont.

- **Ionization energy:**

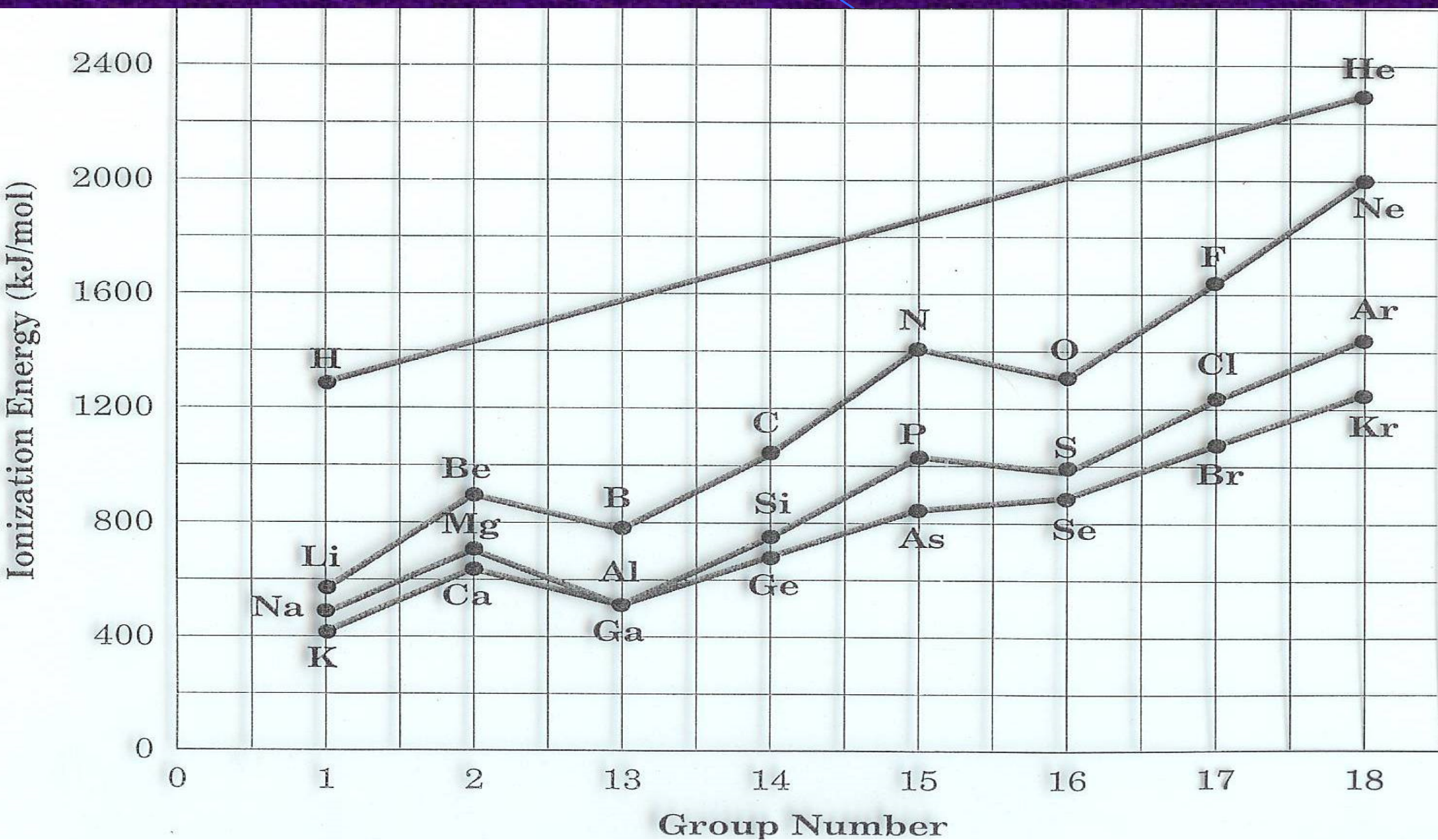
- amount of energy required to pull an electron away from an atom to form a positively charged ion

- generally increases with increasing atomic number

- at some points, when atomic number increases there is a dramatic decrease

ex. Li, Na, K, Rb, Cs, Fr

Trends of Ionization Energy



Trends of Ionization Energy

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 1312																	2 He 2372
2	3 Li 520	4 Be 900											5 B 801	6 C 1086	7 N 1402	8 O 1314	9 F 1681	10 Ne 2081
3	11 Na 496	12 Mg 738											13 Al 578	14 Si 787	15 P 1012	16 S 1000	17 Cl 1251	18 Ar 1521
4	19 K 419	20 Ca 590	21 Sc 633	22 Ti 659	23 V 651	24 Cr 653	25 Mn 717	26 Fe 762	27 Co 760	28 Ni 737	29 Cu 746	30 Zn 906	31 Ga 579	32 Ge 762	33 As 947	34 Se 941	35 Br 1140	36 Kr 1351
5	37 Rb 403	38 Sr 550	39 Y 600	40 Zr 640	41 Nb 652	42 Mo 684	43 Tc 702	44 Ru 710	45 Rh 720	46 Pd 804	47 Ag 731	48 Cd 868	49 In 558	50 Sn 709	51 Sb 834	52 Te 869	53 I 1008	54 Xe 1170
6	55 Cs 376	56 Ba 503	57 La 538	72 Hf 659	73 Ta 761	74 W 770	75 Re 760	76 Os 839	77 Ir 878	78 Pt 868	79 Au 890	80 Hg 1007	81 Tl 589	82 Pb 716	83 Bi 703	84 Po 812	85 At —	86 Rn 1038
7	87 Fr —	88 Ra 509	89 Ac 490	104 Rf —	105 Db —	106 Sg —	107 Bh —	108 Hs —	109 Mt —									

Atomic number
6

Symbol
C

First ionization energy
1086

Lanthanide series

58 Ce 534	59 Pr 527	60 Nd 533	61 Pm 536	62 Sm 545	63 Eu 547	64 Gd 592	65 Tb 566	66 Dy 573	67 Ho 581	68 Er 589	69 Tm 597	70 Yb 603	71 Lu 523
90 Th 587	91 Pa 570	92 U 598	93 Np 600	94 Pu 585	95 Am 578	96 Cm 581	97 Bk 601	98 Cf 608	99 Es 619	100 Fm 627	101 Md 635	102 No 642	103 Lr —

Organizing the Elements Cont.

- * Because other properties of the elements follow the same pattern, it is natural to group the elements according to these intervals

Organizing the Elements Cont.

- each row is commonly referred to as a period
- there are 7 periods
- each period is placed on top of each other, giving rise to columns, known as a group

Organizing the Elements Cont.

- slight modifications of He; nothing in common with the 2nd elements of the other periods
 - Helium moves right until it is aligned with other similar elements such as Ne, Ar, and other noble gasses
 - 2nd period we slide B through Ne
 - 3rd period we slide Al through Ar

Results of Organization

7 periods (Across)

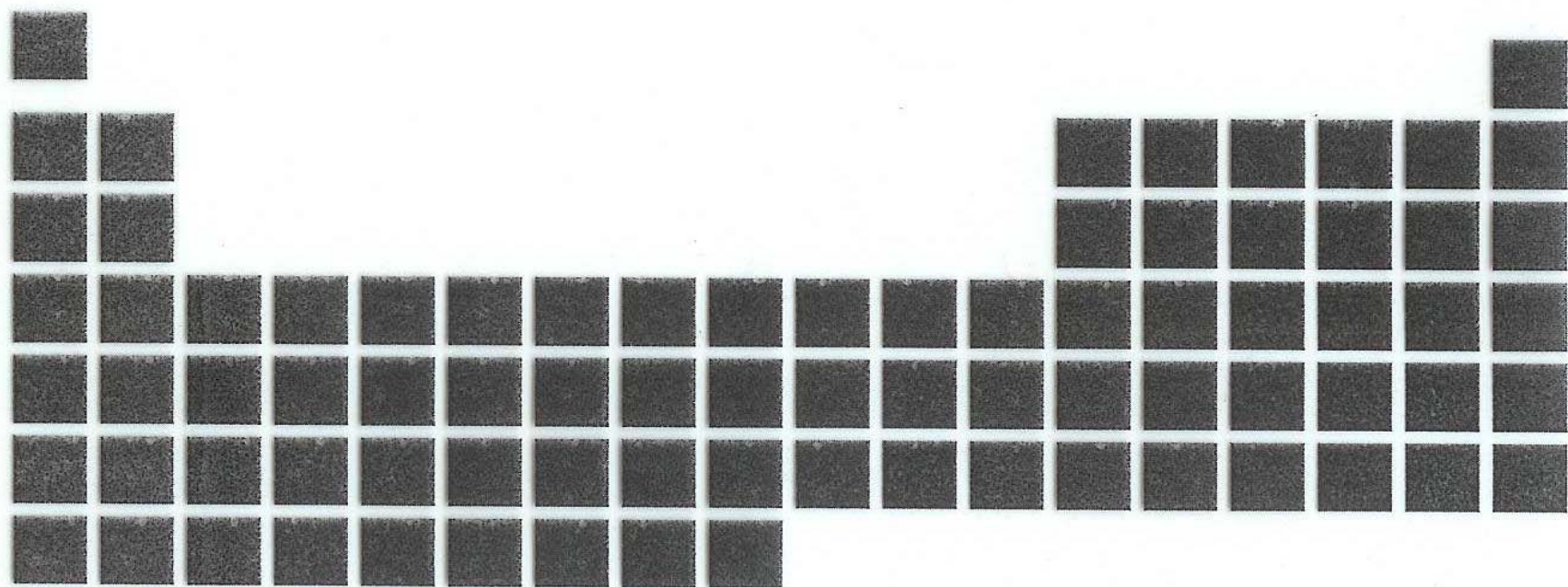
- Atomic Radius decreases
- Ionization energy increase
- Electron Affinity increases

18 Groups (Down)

- Atomic Radius increases
- Ionization energy decreases
- Electron affinity decreases
- Elements have similar chemical and physical properties
- # of valence electrons are the same

Organizing the Elements Cont.

↓ Electronegativity decreases
↓ Shielding effect increases
↓ Ionization energy decreases
↓ Electron affinity decreases
↓ Atomic radius increases



Electronegativity increases →
Shielding effect is constant →
Ionization energy increases →
Electron affinity increases →
Atomic radius decreases →

Objectives

- **Identify general properties of the metals, non metals, and metalloids.**
- **Describe how properties of elements change across a period in the periodic table**

How are Elements Classified?

- Three Regions

- metals, and nonmetals, and metalloids

Group 1	Group 2		Groups 3-12										Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
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 Db	106 Sg	107 Bh	108 Hs	109 Mt										
			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		

Metals

■ Metals

- include group 1 -12 and some elements from 13 - 16
- most known elements
- good conductors of electricity/heat
- solid at room temperature, except mercury
ex. Na, Ag, Pb

Non Metals

■ Definition

- elements that are poor conductors of electricity/heat
- low boiling points, SO...most are gases at room temperature
- varying chemical properties

ex. He, F, P

Metalloids

■ Definition

- elements with properties that fall between those of metals and non metals
 - chemical properties will vary, usually most like the region they are closer to
 - ex. As: closer to non metal most of it's property will resemble that

Families of the Periodic Table

- **Families/Groups**

Alkali metals

Alkali Earth metals

Boron Family

Carbon Family

Nitrogen Family

Oxygen

Transition Metals

Halogens

Noble Gases

Alkali Metals

▪ Definition

- highly reactive metallic elements in group 1
- react with water to form hydrogen and alkaline solutions; burn in air
- al-quili means wood ashes
- term dates back to ancient times; people discovered that wood ashes mix with water to produce slippery solutions that can remove grease
- one outer electron, by losing this electron they become a cation, and become stable

Alkali Metals Cont.

- soft metals; can be cut with a knife
- shiny, but dull quickly due to oxygen and water in air
- good conductors
- gaseous states at high temperatures become plasmas

ex. Na, Cs, Rb

Alkali-Earth Metals

- Definition

- group 2 elements

- comes from idea of “Earth”, materials unable to light on fire

- reactive metallic elements with two electrons in the outermost energy level

- harder, denser, stronger and have higher melting points, lower reactivity than alkali

ex. Be, Ca, Mg

Transition Metals

■ Lanthanides

- shiny, metallic transition metals (58 – 71) in which electrons are added to 4f orbitals
- located at the bottom of the periodic table for convenience

■ Actinides

- shiny metallic transition metals (90 – 103) in which electrons are added to 5f orbitals
- located at the bottom of the periodic table for convenience
- radioactive

Halogens

▪ Definition

- nonmetallic elements in group 17, that have 7 electrons in the outer most energy level and combines with many metals to form salts

- term comes from Greek means “salt former”

Salt: a compound composed of positive and negative ions arranged in a regular 3D pattern

- most reactive group of nonmetals

- varying physical properties, similar chemical properties

Noble Gas

■ Definition

- elements in group 18 that are characterized by low reactivity
- term comes from noble people, did not associate with anyone other than their kind
- characterized by an octet of electrons in the outermost energy level; (happy)
 - exception of helium
- very stable, (unreactive)
- colorless, odorless
- practical applications: balloons, illumination

Hydrogen

- most common element in the universe
- behaves unlike any other element due to its structure of 1 p 1 e
- react with numerous elements
- component of all hydrocarbons, and molecules that are essential to life; fats, proteins, carbohydrates
- practical uses
 - ex. ammonia, fertilizers