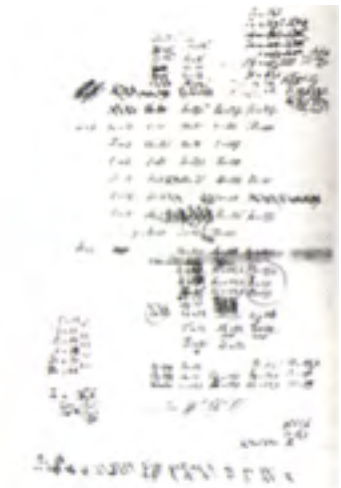
Trends in the Periodic Table

OBJECTIVES FOR TODAY:

- Fall in love with the Periodic Table, Interpret group and period trends in atomic radii, ionization energies and electronegativity

The Periodic Table

- What is the periodic table ?
- What information does the table provide ?
- How can one use the periodic table to predict the properties of the elements?



Dmitri Mendeleev

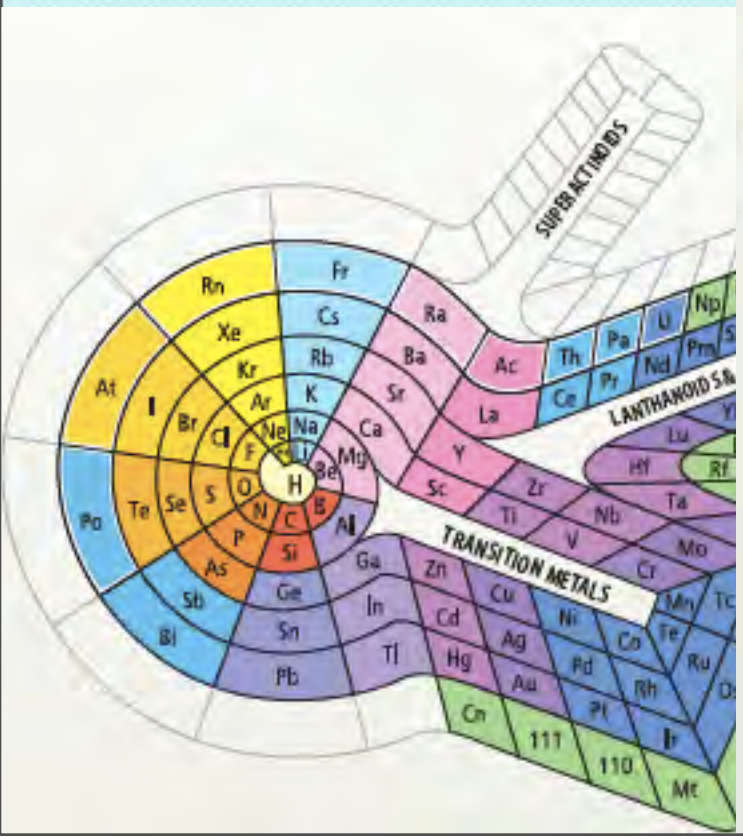
Early Table

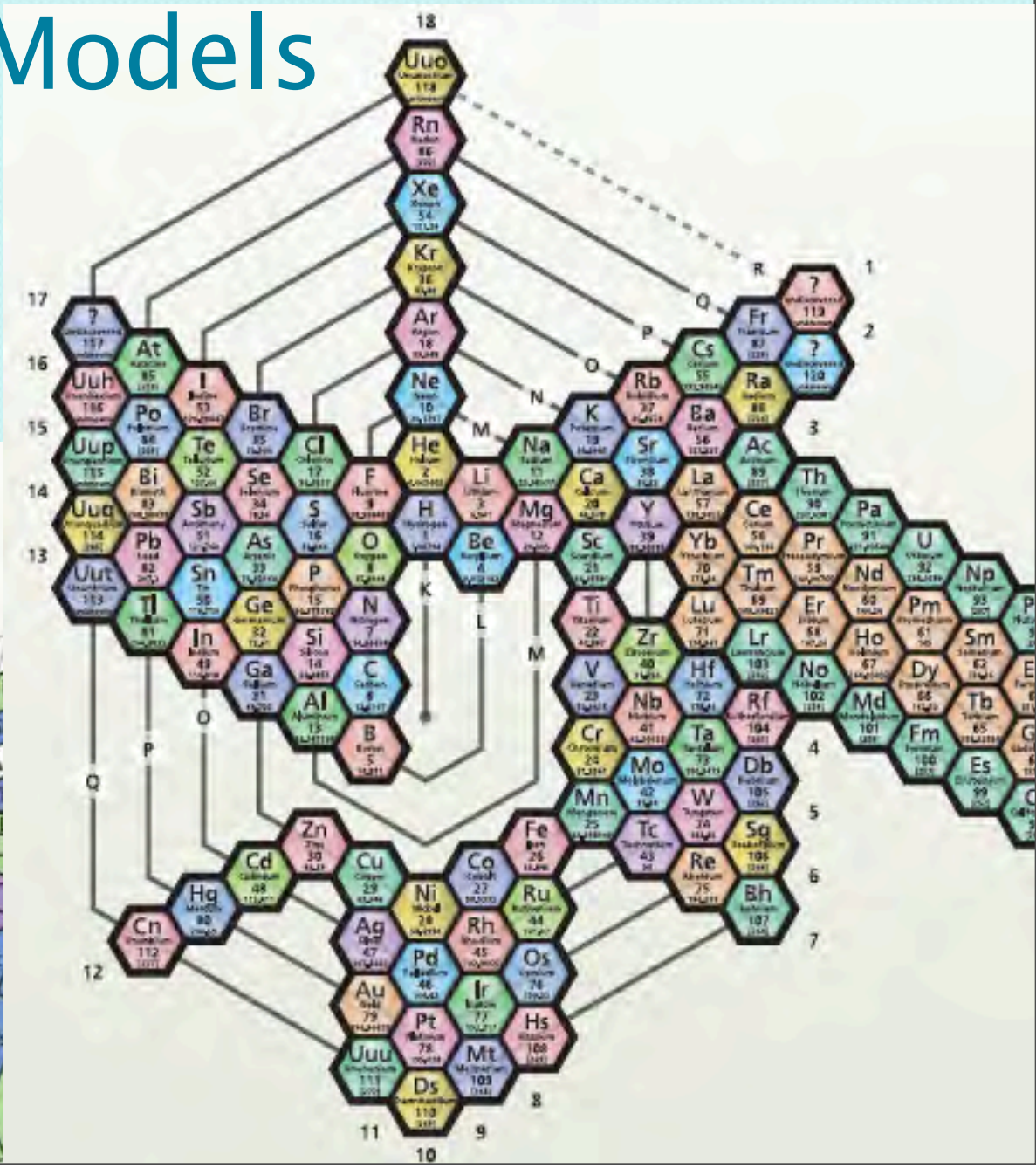
TABELLE II

REIHEN	GRUPPE I. — R^2O	GRUPPE II. — RO	GRUPPE III. — R^2O^3	GRUPPE IV. RH^4 RO^2	GRUPPE V. RH^3 R^2O^5	GRUPPE VI. RH^2 RO^3	GRUPPE VII. RH R^2O^7	GRUPPE 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	J=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	—	— — — —

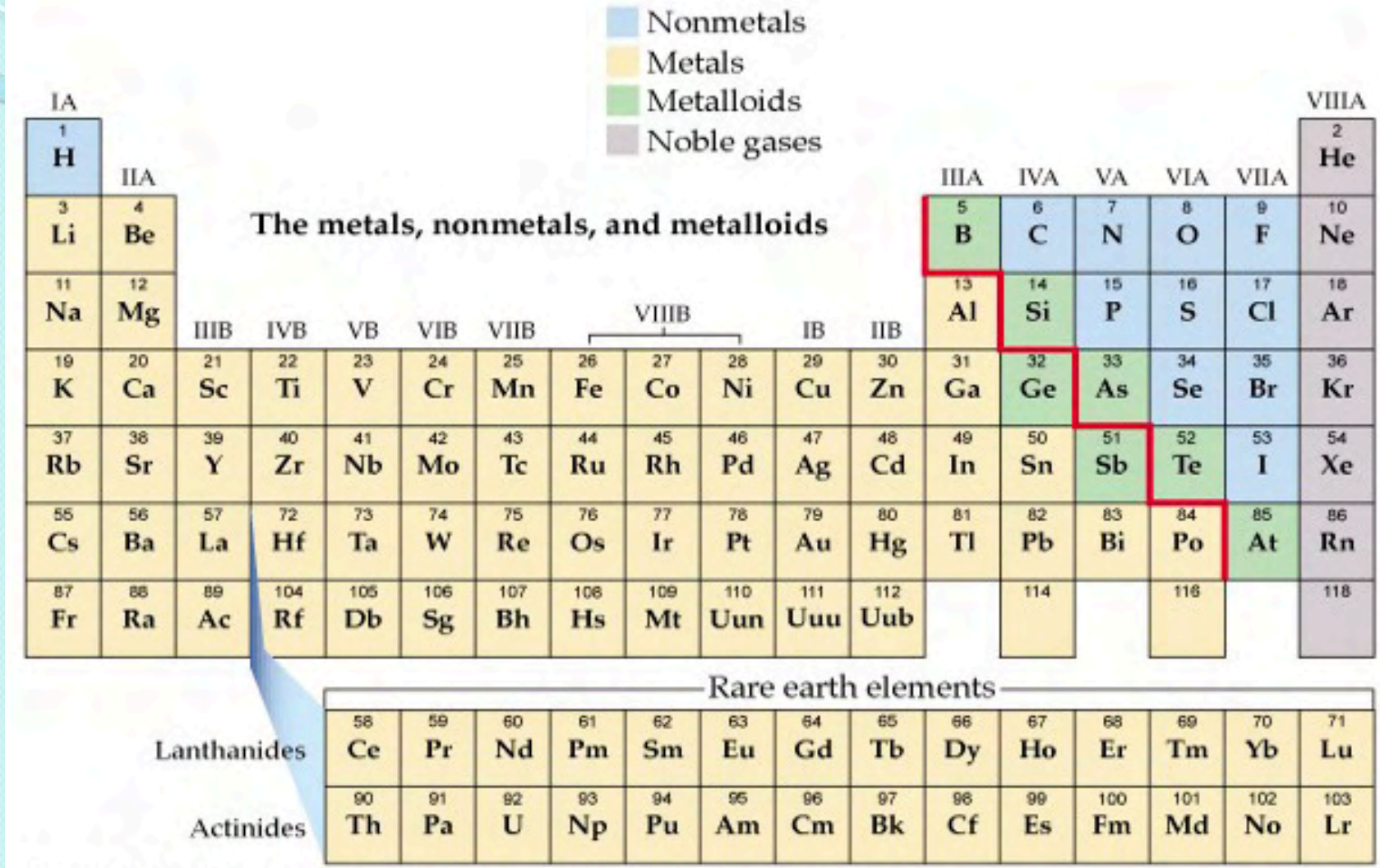
Figure 2.5 Dmitri Mendeleev's 1872 periodic table. The spaces marked with blank lines represent elements that Mendeleev deduced existed but were unknown at the time, so he left places for them in the table. The symbols at the top of the columns (e.g., R^2O and RH^4) are molecular formulas written in the style of the 19th century.

Alternative Models





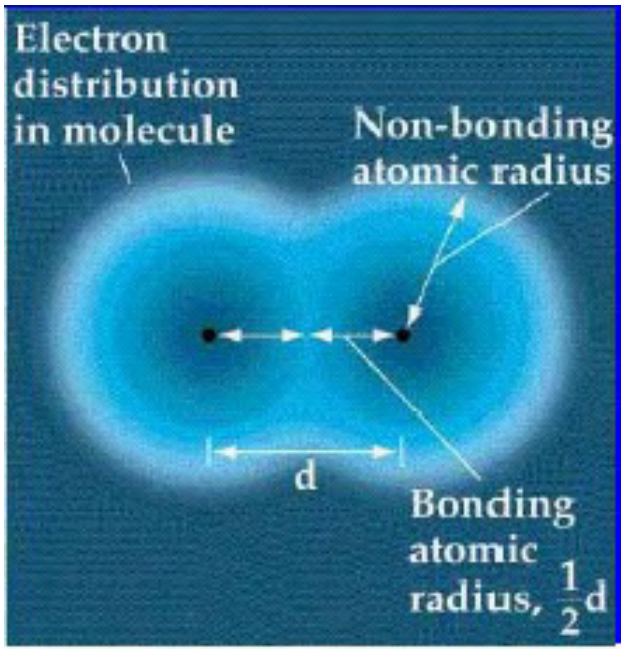
Modern Periodic Table

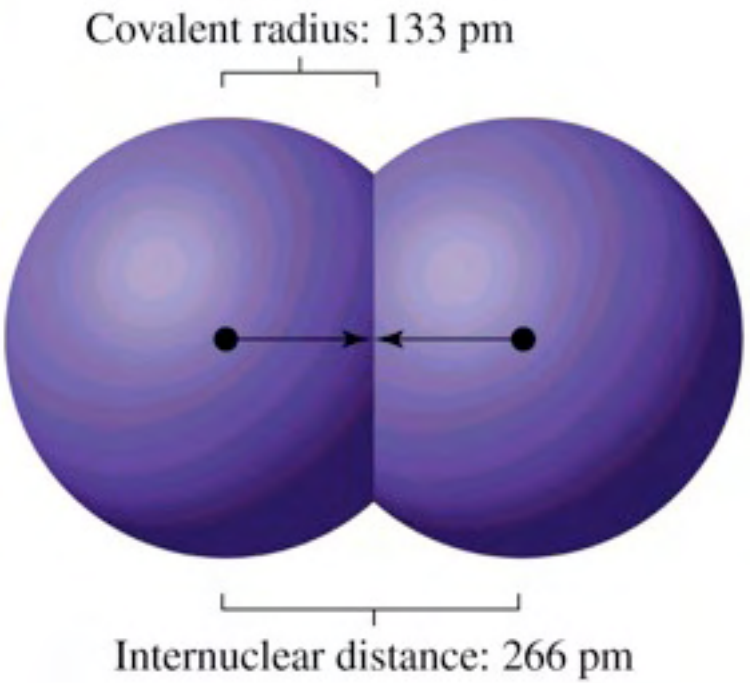


Trends in Atomic Size

- Where are the biggest atoms???
- First problem: Where do you start measuring from?
- The electron cloud doesn't have a definite edge.
- They get around this by measuring more than 1 atom at a time.

Atomic Size





Atomic Radius = half the distance between two nuclei of a diatomic molecule.

Trends in Atomic Size

Influenced by three factors:

1. Energy Level
   - Higher energy level is further away.
2. Charge on nucleus
   - More charge pulls electrons in closer.
3. Shielding effect

   electron-electron repulsion

H

Li

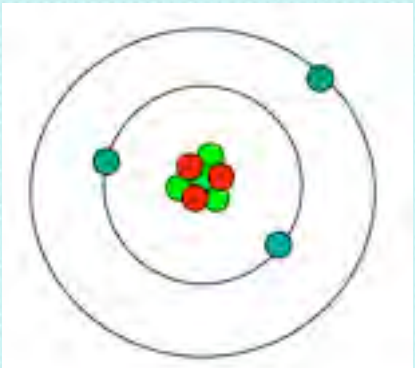
Na

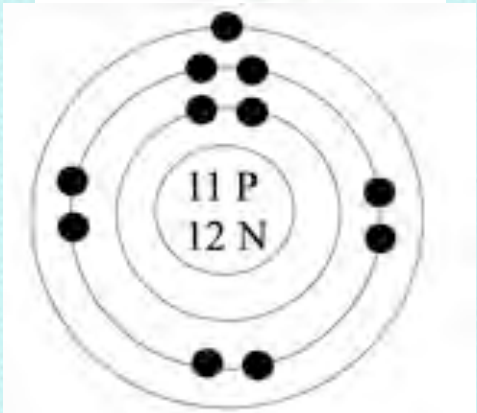
K

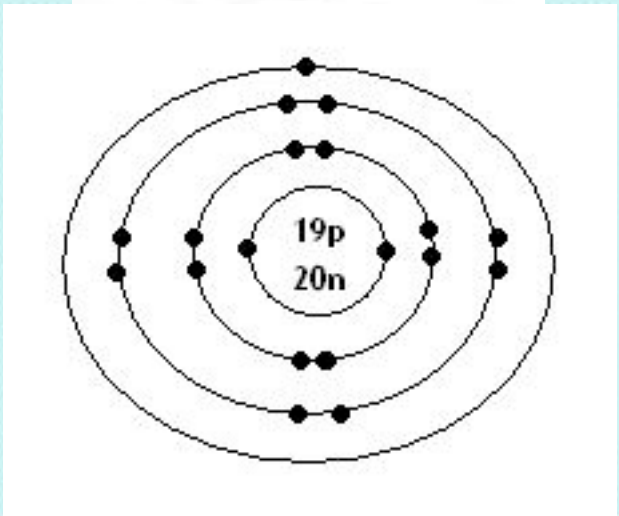
Rb

Group trends

- As we go down a group...
- each atom has another energy level,
- so the atoms get bigger.

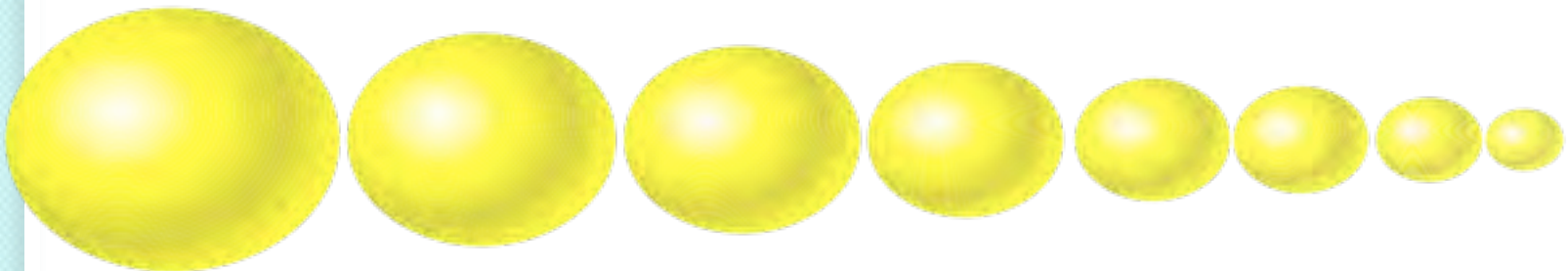




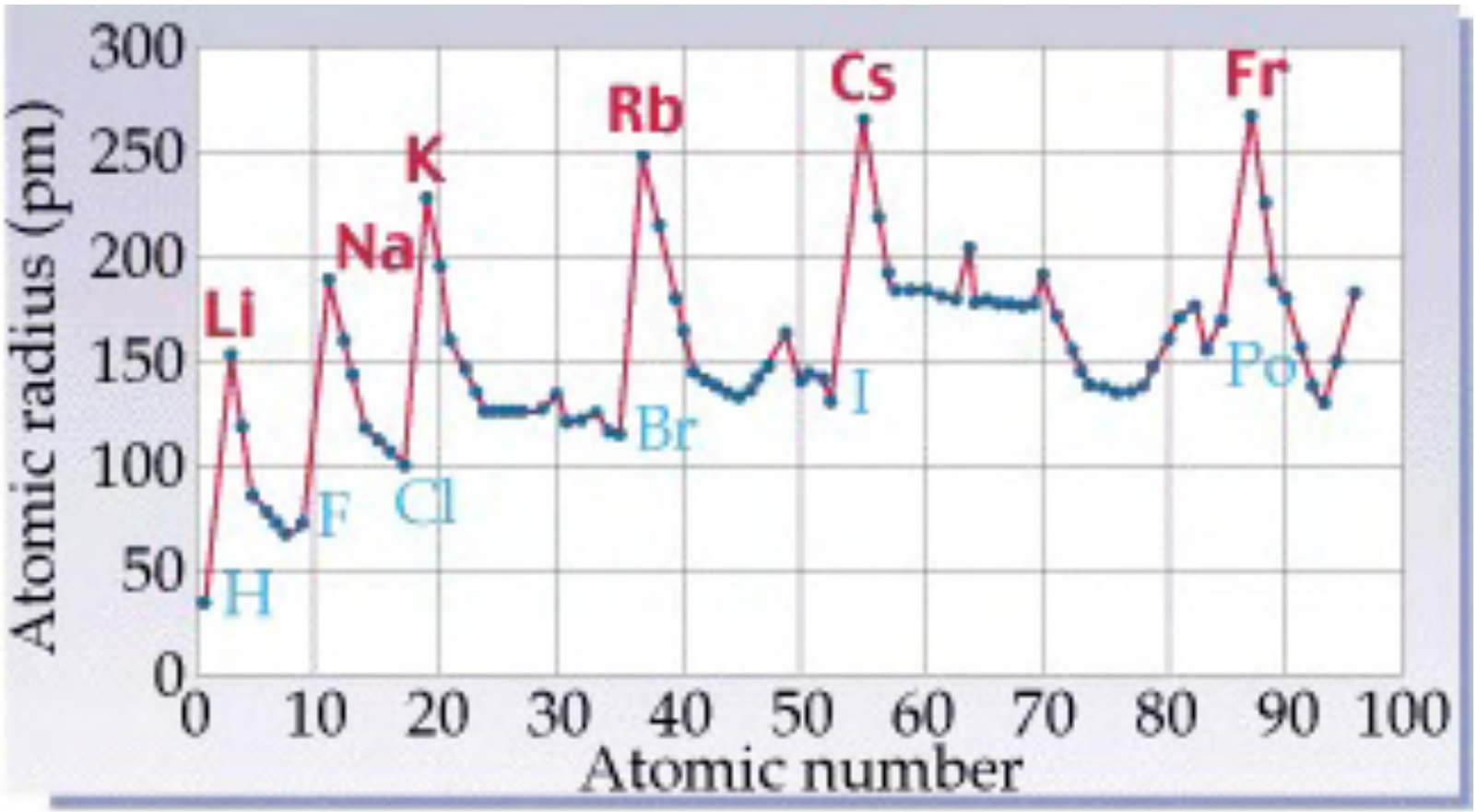


Periodic Trends

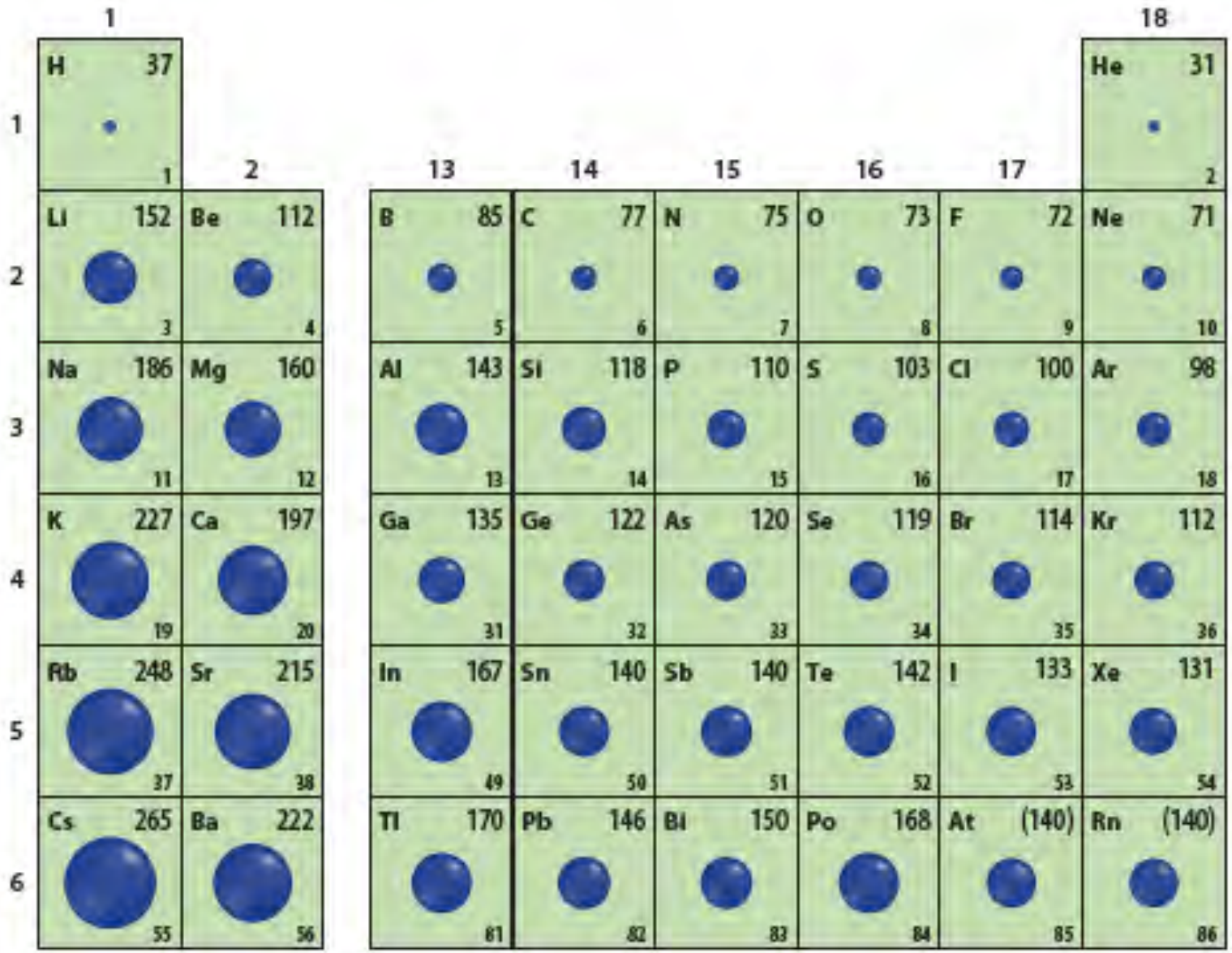
- As you go across a period, the radius gets smaller.
- Electrons are in same energy level.
- More protons = holding electrons tighter
- Outermost electrons are closer.



Atomic Radii Trend



Atomic Radii



Ionization Energy

- The minimum amount of energy required to completely remove the outermost electron from a gaseous atom of the element.
- Removing an electron makes a +1 ion.

$$A(g) + \text{energy} \rightarrow A^+(g) + e^- \text{ (first ionization)}$$

- The energy required to remove the first electron is called the first ionization energy.

Ionization Energy

- The second ionization energy is the energy required to remove the second electron.
  - Always greater than first IE.
- The third IE is the energy required to remove a third electron.
  - Greater than 1st or 2nd IE.

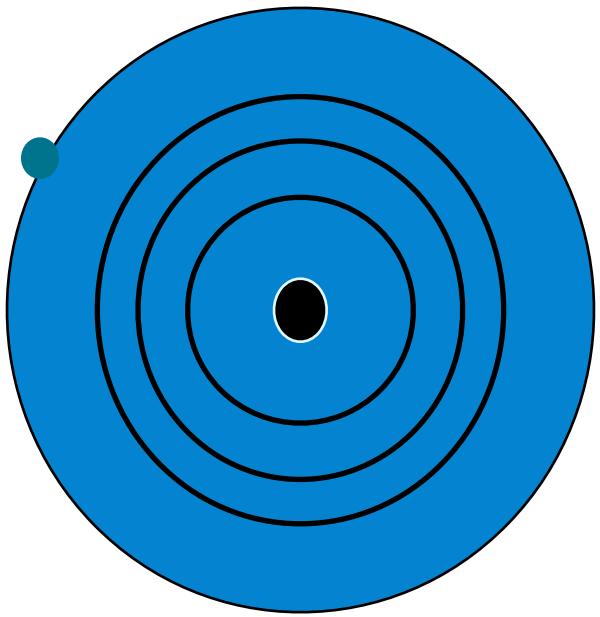
Symbol	First	Second	Third
H	1312		
He	2731	5247	
Li	520	7297	11810
Be	900	1757	14840
B	800	2430	3569
C	1086	2352	4619
N	1402	2857	4577
O	1314	3391	5301
F	1681	3375	6045
Ne	2080	3963	6276

What determines IE

- Think about whether the electron wants to give up that electron!
- Greater distance from nucleus decreases IE
- Shielding effect (inter-electron repulsion)

Shielding

- The electron in the outermost energy level experiences more inter-electron repulsion (shielding).
- Second electron experiences the same shielding, if it is in the same period

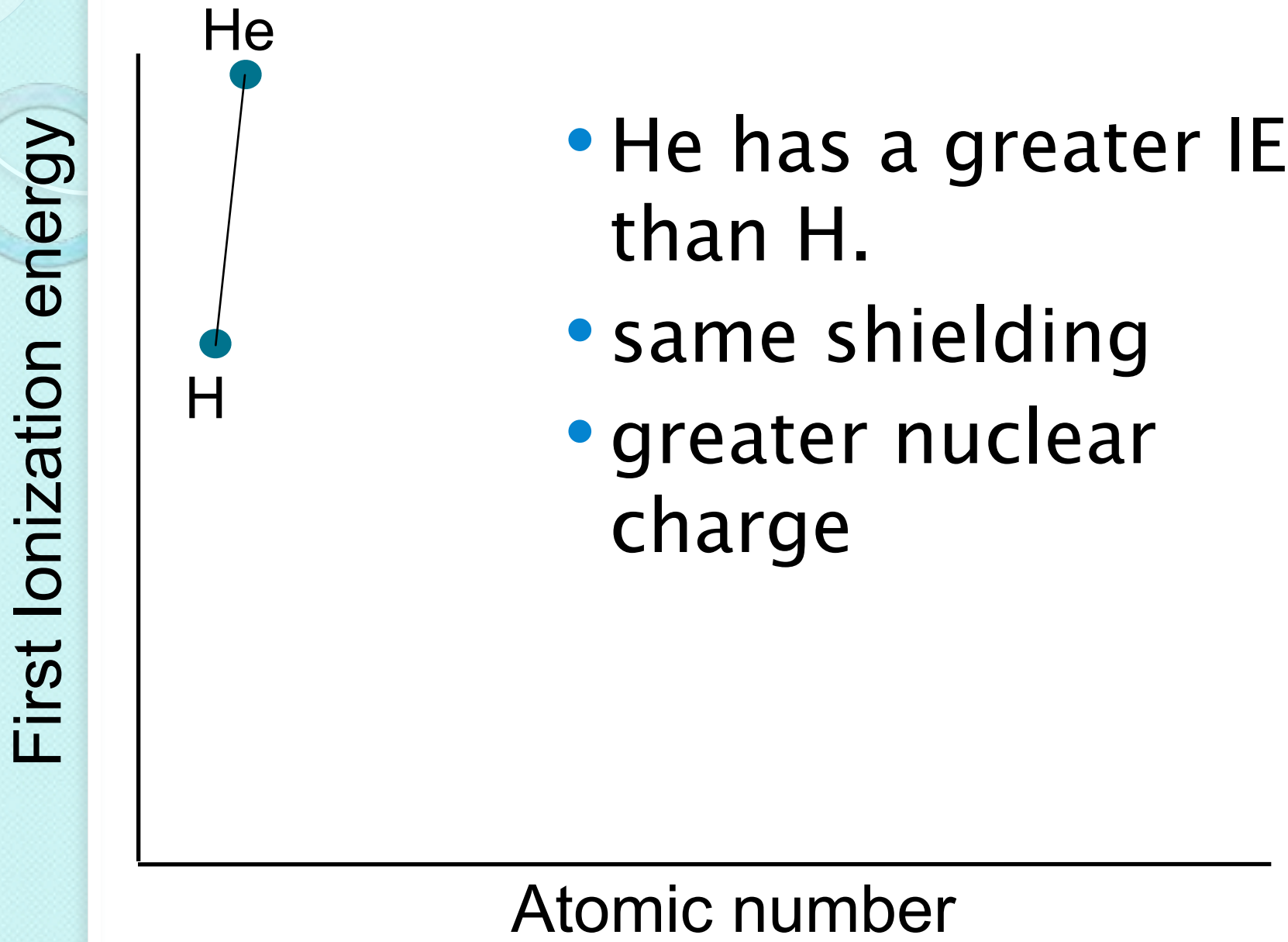


Group trends

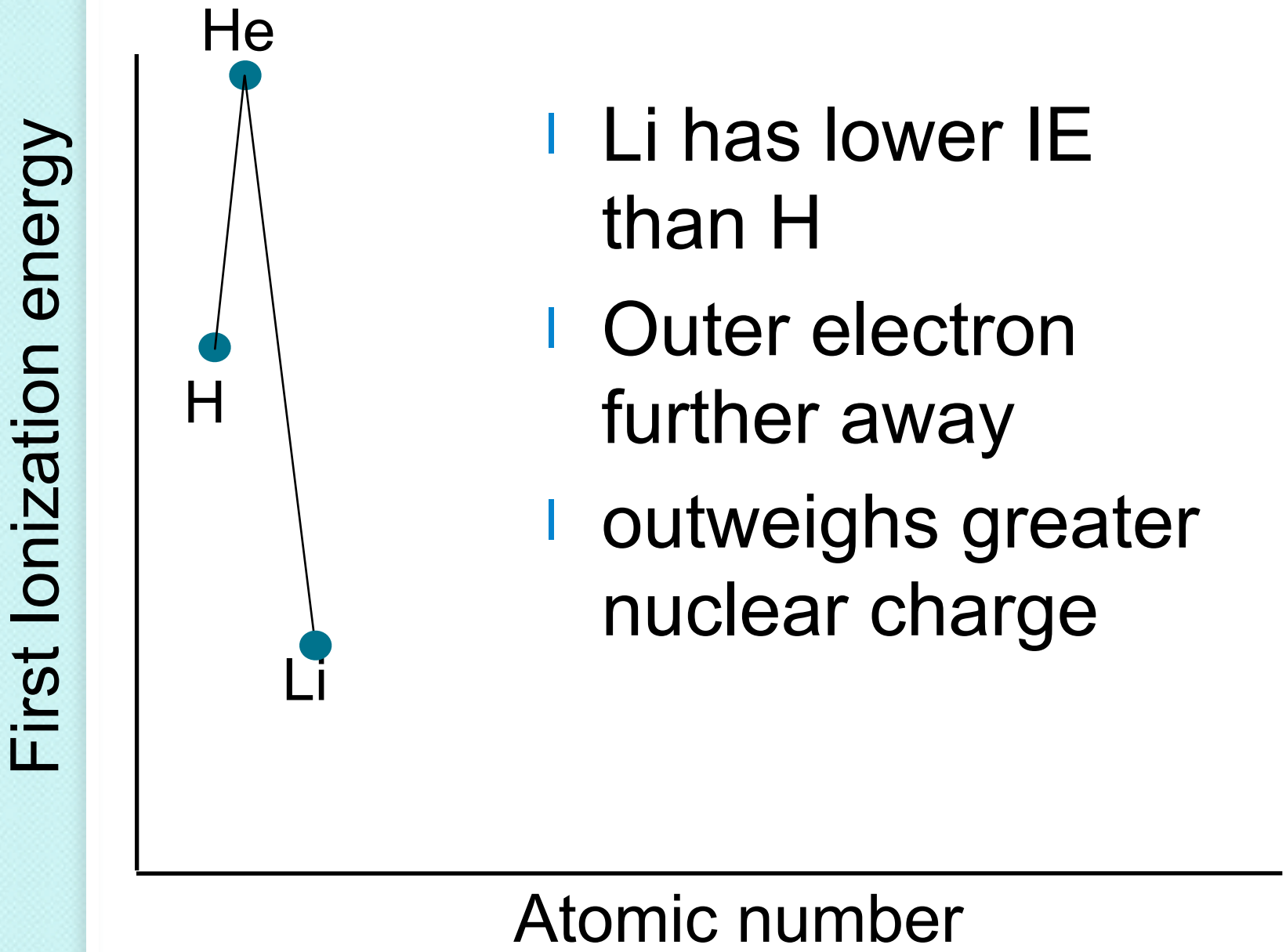
- As you go down a group, first IE decreases.
- The outer electron is further away from the nucleus because there are more energy levels.
- Shielding increases as does nuclear charge.

Periodic trends

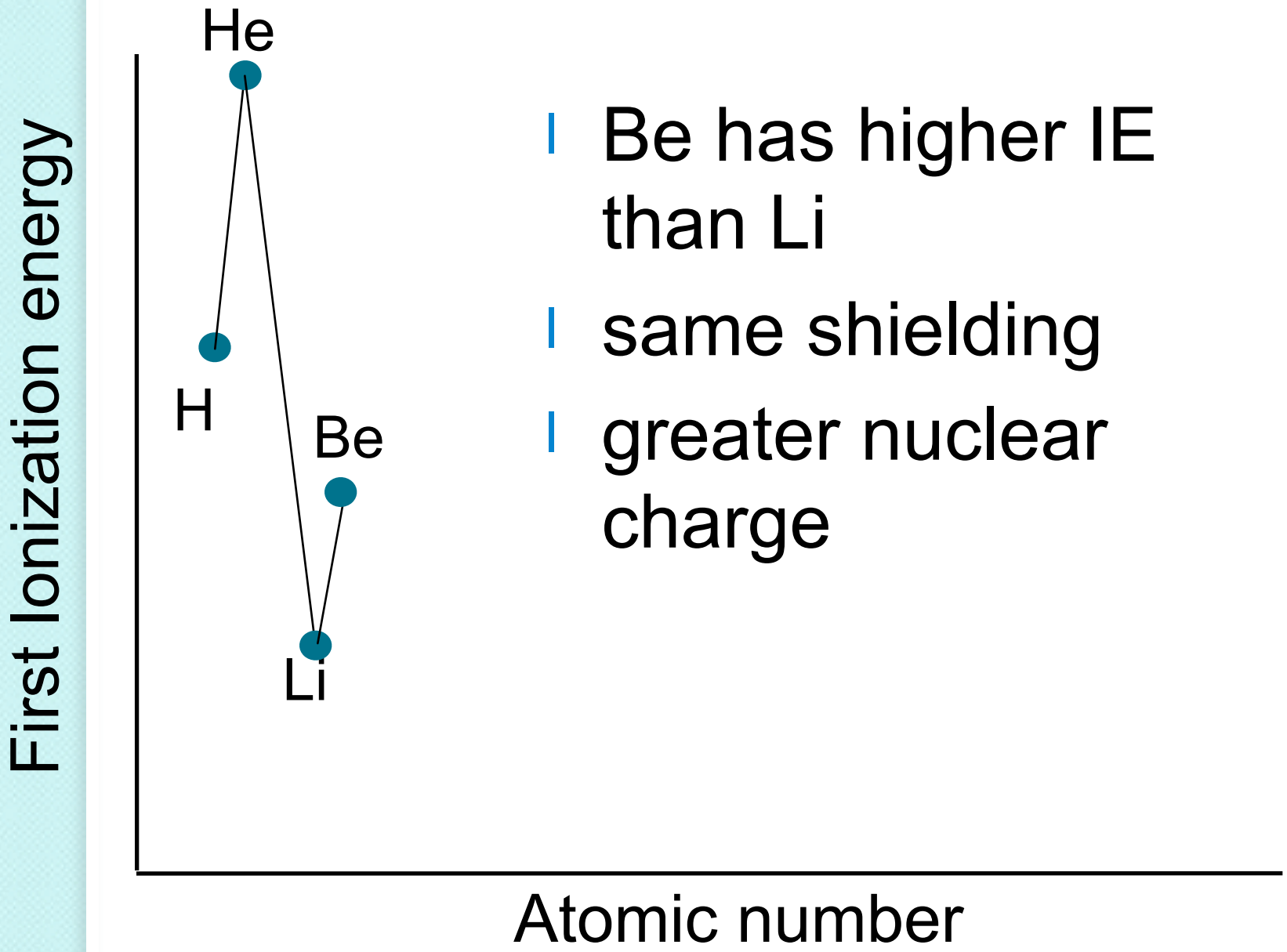
- All the atoms in the same period have the same energy level.
- Same shielding.
- But, increasing nuclear charge
- So IE generally increases from left to right.



- He has a greater IE than H.
- same shielding
- greater nuclear charge



- Li has lower IE than H
- Outer electron further away
- outweighs greater nuclear charge

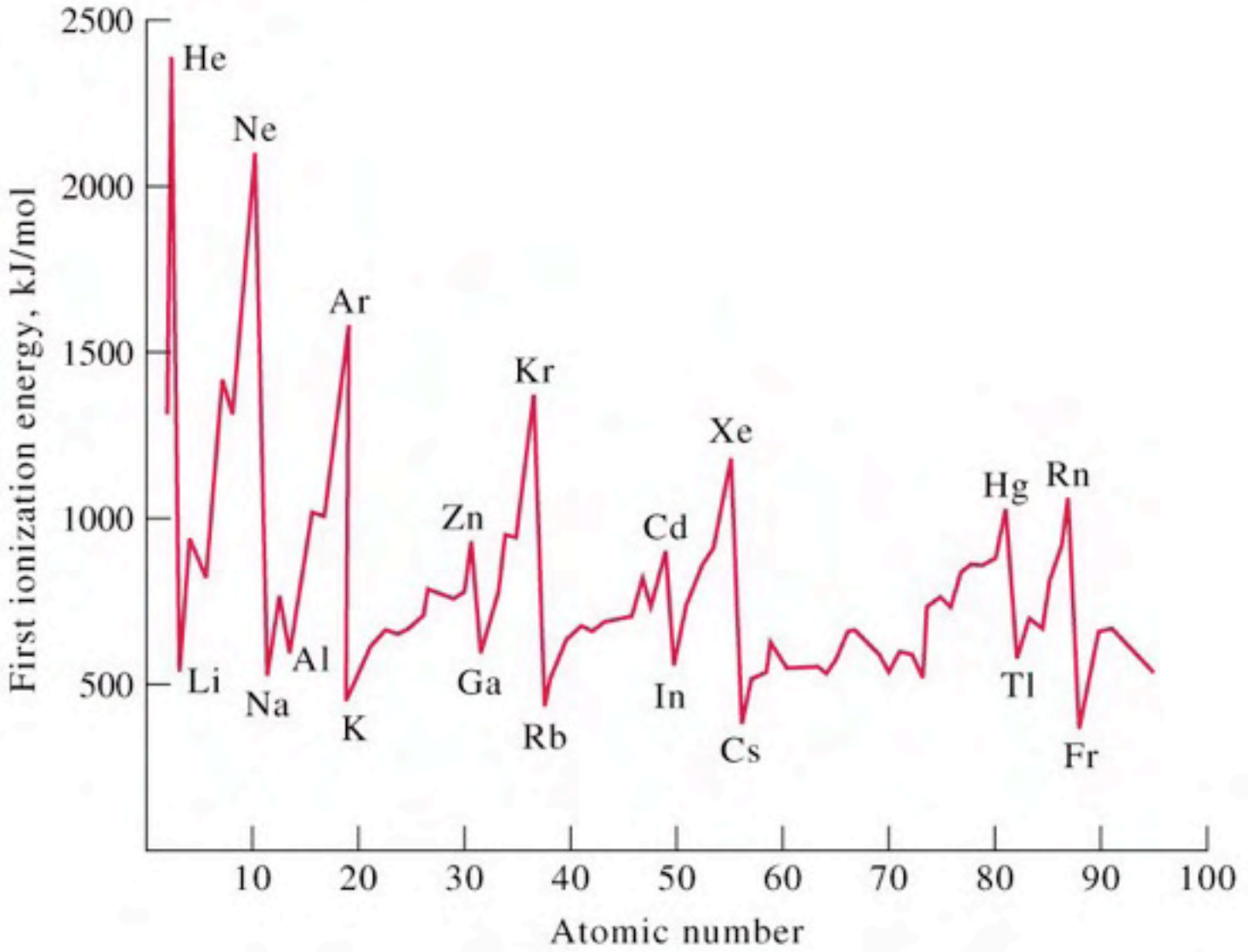


- Be has higher IE than Li
- same shielding
- greater nuclear charge

Driving Force

- Full Energy Levels require lots of energy to remove their electrons.
- Noble Gases have full orbitals.
- Atoms behave in ways to achieve noble gas configuration.

First Ionization Energies



Electronegativity

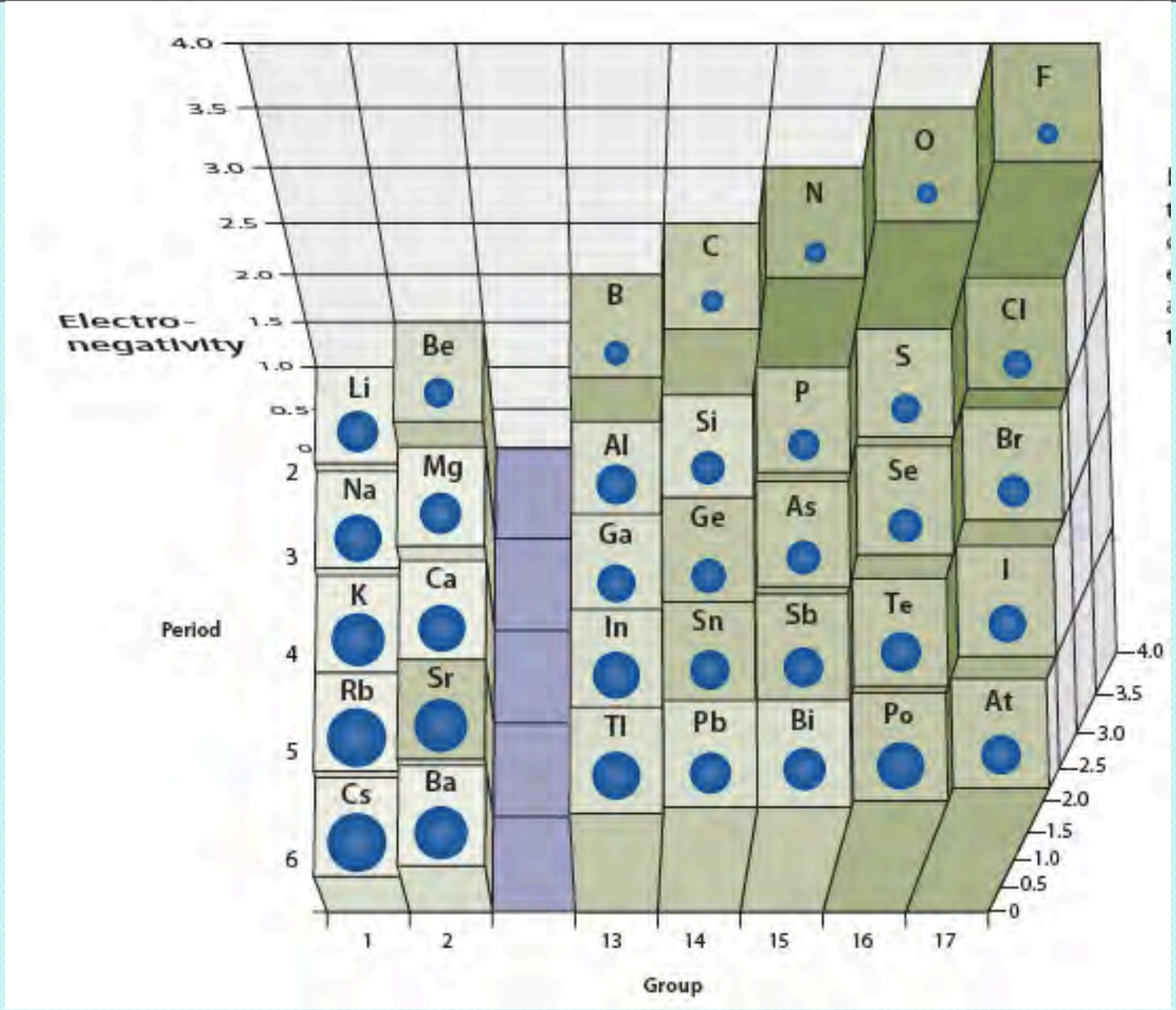
- The tendency for an atom to attract electrons to itself when it is chemically combined with another element.
- High electronegativity means it pulls the electron toward it.
- Atoms with large negative electron affinity have larger electronegativity.

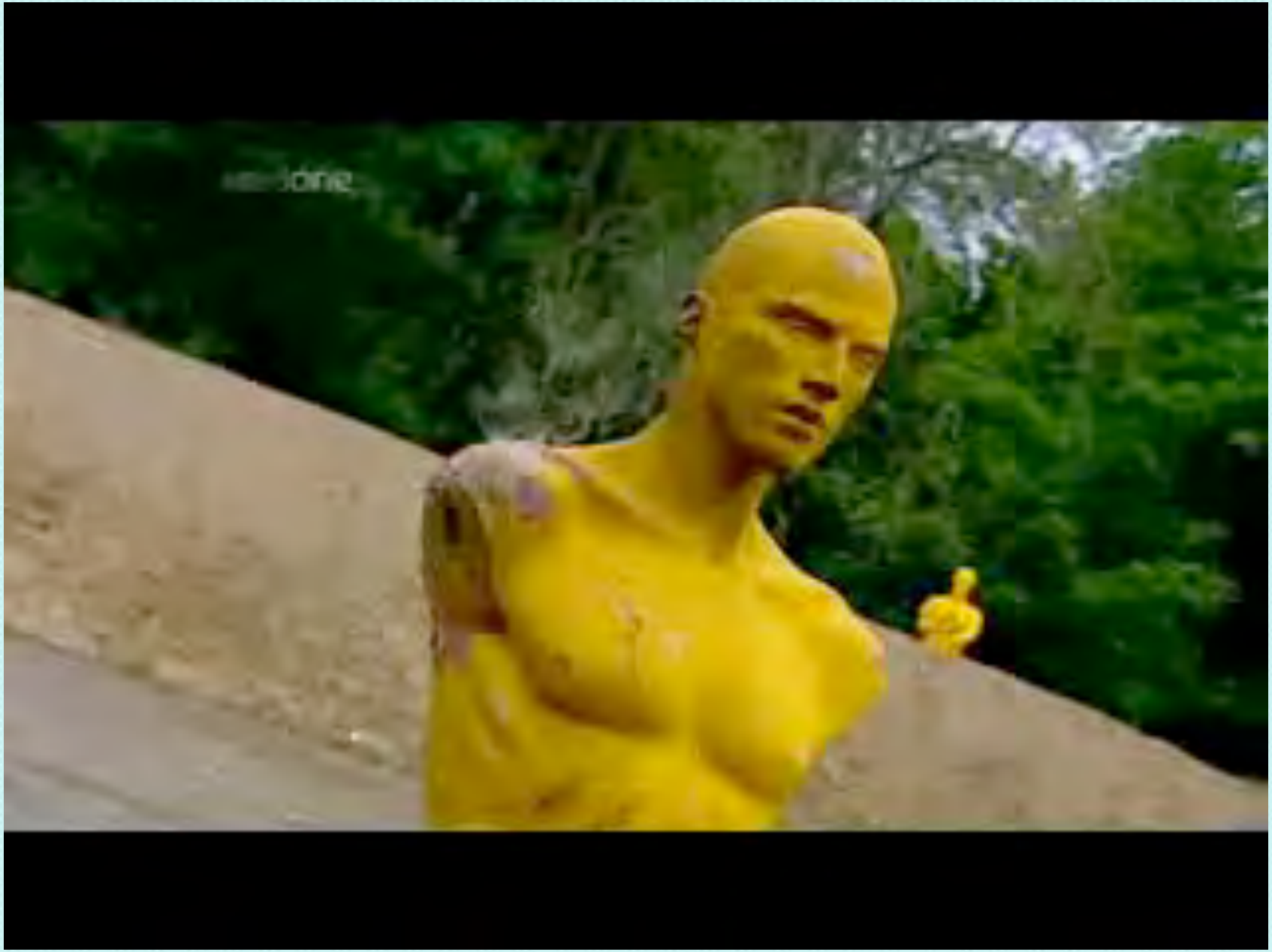
Group Trend

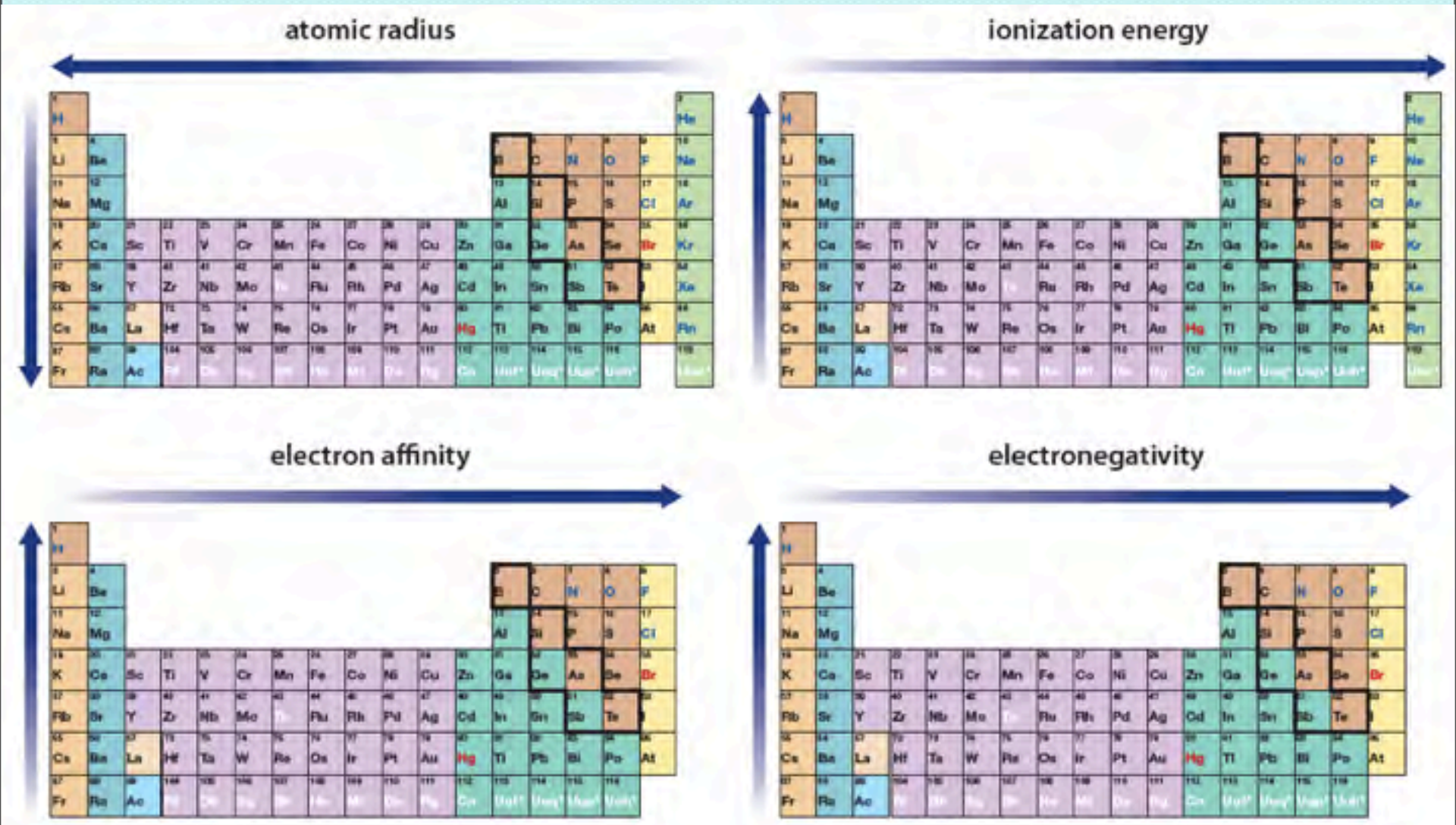
- The further down a group, the farther the electron is away, and the more electrons an atom has.
- More willing to share.
- Low electronegativity.

Periodic Trend

- Metals are at the left of the table.
- They let their electrons go easily
- Low electronegativity
- At the right end are the nonmetals.
- They want more electrons.
- Try to take them away from others
- High electronegativity.


Electro-
negativity
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Period
2
3
4
5
6
Li
Be
B
C
N
O
F
Na
Mg
Al
Si
P
S
Cl
K
Ca
Ga
Ge
As
Se
Br
Rb
Sr
In
Sn
Sb
Te
I
Cs
Ba
Tl
Pb
Bi
Po
At
1
2
13
14
15
16
17
Group




atomic radius
ionization energy
electron affinity
electronegativity