# Group Clicker Question



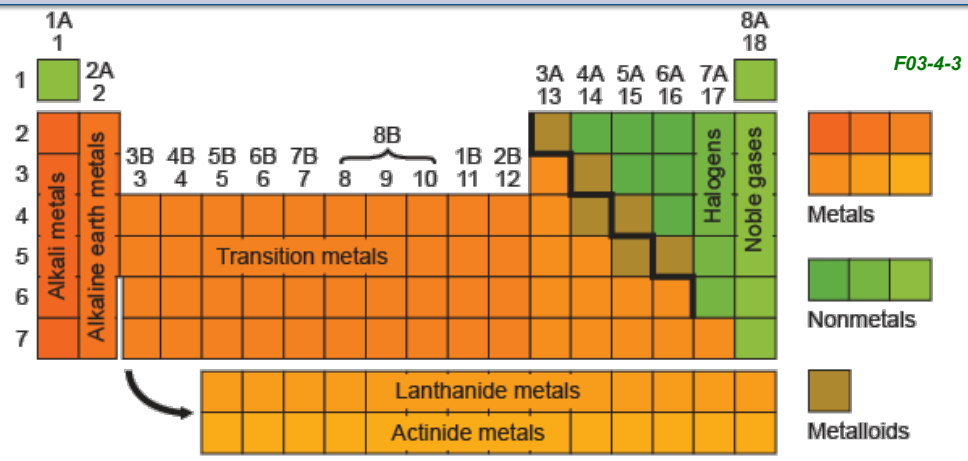
# *Lesson 04-1 to 04-3*
# *Periodic Properties*

***Lesson Goals:***

- Use the Periodic Table to write electron configuration
- Know why groups/families have similar chemical behavior
- Predict periodic trends in atomic size
- Predict periodic trends in ionization energy
- Identify core or valence electrons by the relative amount of energy required for removal

## The periodic table of the elements summarizes a lot of information about the elements.

Rows are Periods or Shells, Columns are Groups or Families




**Elements in the same family have similar properties!**



## The Properties of Elements are related to their Structure.

*Structure of the atom = Nucleus + Electron Configuration*

**So, the atomic number and the electron configuration determine:**

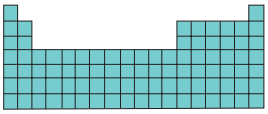
- ⌘ **the organization of the Periodic Table**
- ⌘ **the properties of the elements**
  - ➢ **Atomic size**
  - ➢ **Ionization energy**
  - ➢ **Electron affinity**
  - ➢ **Chemical reactivity**

Electron configuration is the reason for periodic trends in element behavior

# Understanding Periodic Trends

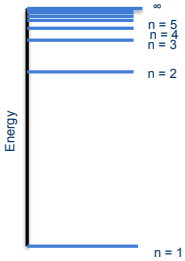
$$E = -\frac{hcR_H\left(Z_{eff}^2\right)}{n^2}$$

$$E \propto \frac{Q_1 Q_2}{d}$$



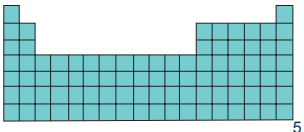
As n ↑

- Energy of atomic orbitals _____
- e⁻ interaction with nucleus is _____
- Orbitals are **less** stable energy states




As Z ↑

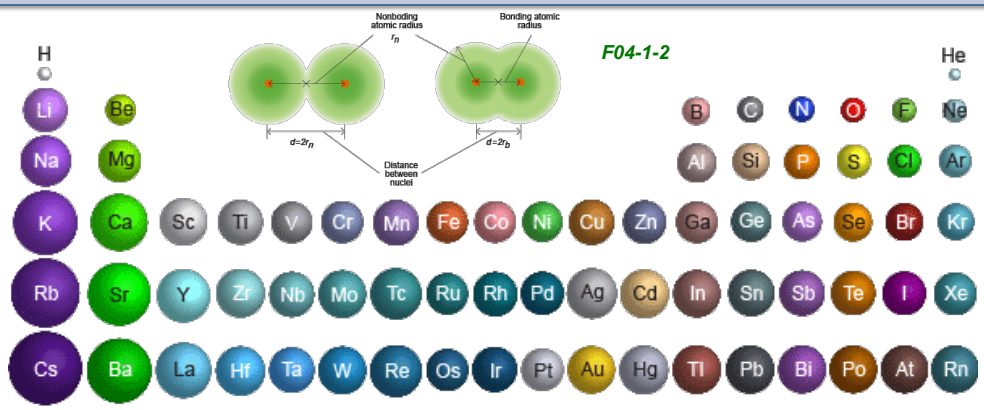
- # protons in the nucleus _____
- (within period) $Z_{eff}$ ↑ (shielding is _____)
- (within period) e⁻ interaction with nucleus is _____
- Energy of that atomic orbital _____
- Orbitals are **more** stable energy states





# Atomic size (radius) INCREASES top to bottom down a group

**Atomic radius is half the distance between bonded atoms**




F04-1-4

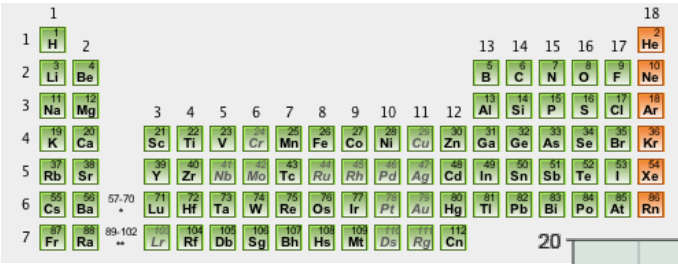
As n increases, what happens to **orbital** size?

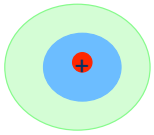
What happens to atomic size within a shell (left to right)?



*Click to expand F04-1-4* | *Click the arrow for transition metal sizes in F04-1-4*

# $Z_{eff}$ increases going from left to right across a period

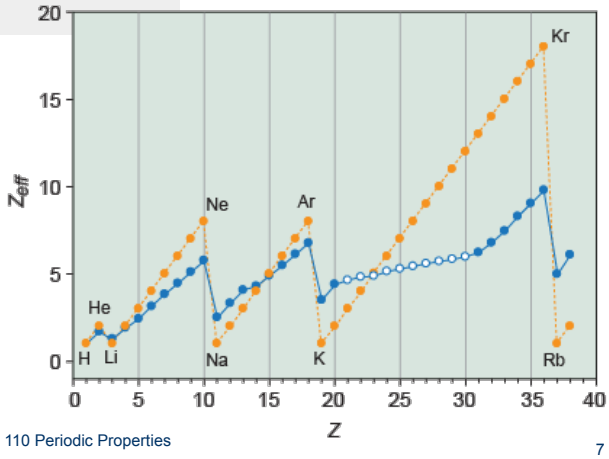




F04-1-1

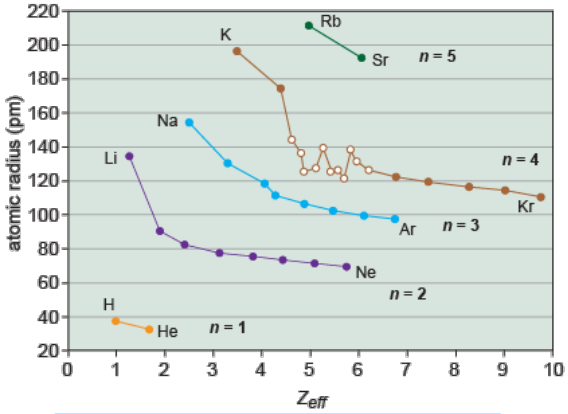
As Z increases;

- Number of protons increases
- Core stays the same shielding strength
- Added valence e⁻s shield poorly
- $Z_{eff}$ increases
- Electrons are drawn closer to nucleus
- Size decreases



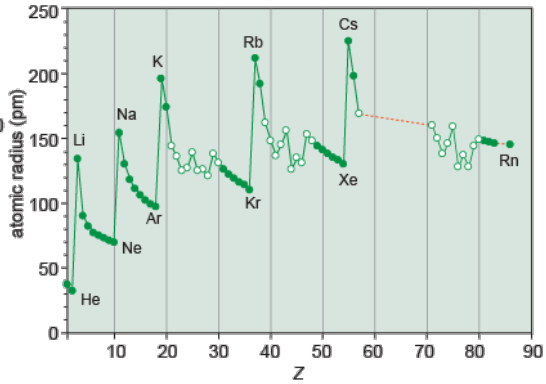



# As $Z_{eff}$ increases, Atomic size DECREASES left to right across a period




*First rank size according to n, then rank according to $Z_{eff}$*

F04-1-5



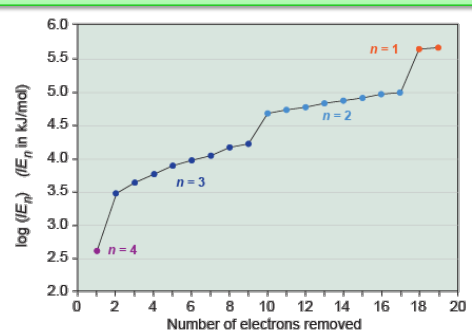

- **As n increases, the shell size gets larger.**
- **Within a shell (same n), the size gets smaller as the number of protons increases.**

# Clicker Question



**IONIZATION ENERGY** is the energy needed to remove an electron from a gaseous atom or ion

Ionization Energy is always POSITIVE (endothermic)




Ionization Energy trend for $_{19}K$ shows successive removal of electrons from the ***same atom***

*F04-2-1*

**$IE_1$ is first ionization energy**

**$IE_2$ is second ionization energy**

**($IE_3$ etc., continue until all electrons removed)**

## Outer (valence) electrons are more easily removed than inner (core) electrons.

Example: Mg $\underbrace{1s^2 2s^2 2p^6}_{\text{[Ne] core electrons}}$ $3s^2$ ← valence electrons

$IE_1$ = 738 kJ/mol product is $Mg^+(g)$

$IE_2$ = 1451 kJ/mol product is $Mg^{+2}(g)$

$IE_3$ = 7733 kJ/mol product is $Mg^{+3}(g)$

**Determine the number of valence electrons by the dramatic jump in IE**



## Clicker Question

| $IE_1$ (MJ/mol) | $IE_2$ (MJ/mol) | $IE_3$ (MJ/mol) | $IE_4$ (MJ/mol) | $IE_5$ (MJ/mol) |
|---|---|---|---|---|
| 0.58 | 1.82 | 2.74 | 11.58 | 14.84 |

**Compare IONIZATION ENERGY for *different atoms*:**
The **further** the electron is from the nucleus
the **easier** it is to remove.

**What is the trend for $IE_1$ across the periodic table left to right?**

| | Na | Mg | Al | Si | P | S | Cl | Ar |
|---|---|---|---|---|---|---|---|---|
| IE? | | | | | | | | |
| Size ? | | | | | | | | |

**What is the trend for $IE_1$ top to bottom going down a family?**

Size?

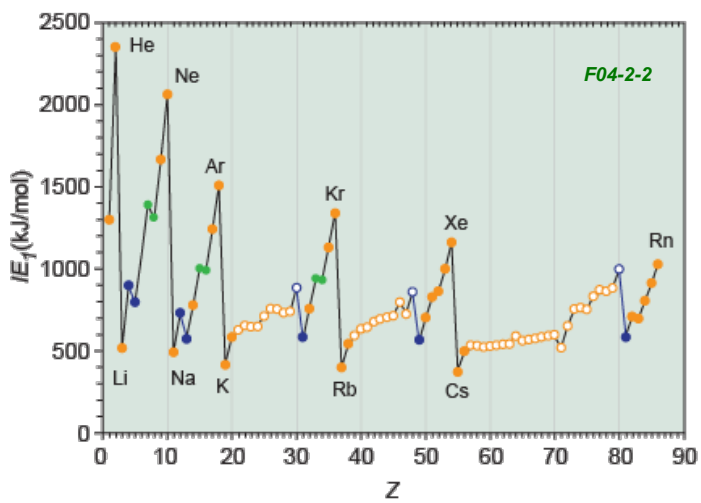
Li
Na
K
Rb
Cs

I.E.?

Which of these is easiest to ionize?

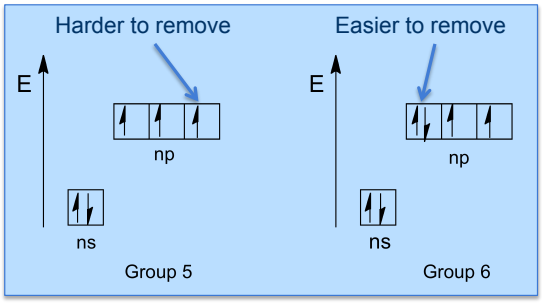


**There are exceptions to the trends in Ionization Energy**




**It takes extra energy to:**

- **Remove electrons from filled subshells (Mg, Ar, Zn)**
- **Remove electrons from half-filled subshells (N, P)**



# Stay on Top of Things!

Before next class:

- Continue the **SP Week 3 Lectures 7-9** homework problems linked to the syllabus. Do the "**related problems**" also.
- **RQ 3** at next Thursday's recitation will be based on Week 3 HW and paired problems. BRING THE RECITATION WORKSHEET!!
- Do **Quiz 3** on Angel by midnight **Thursday** (Wk 3 HW)
- Finish **ALEKS Objective 3** by Tuesday at midnight
- Midterm Exam **Conflict signups** are due **Wed. Feb. 4** on Angel
- Read **Lessons 04-4 to 04-5**, including the solved problems, applets and stop signs.



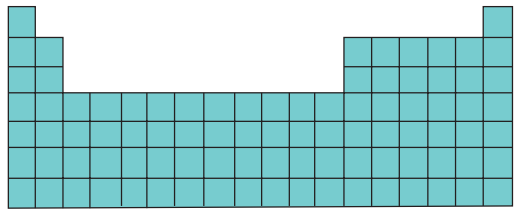
# Appendix;
# Cover this material on your own to add to your knowledge

## Elements in the same column (group/family) have the same valence shell configuration.

Location on the periodic table is related to electron configuration

**Alkali metals (Group 1/1A) have a $ns^1$ valence configuration**

| | |
|---|---|
| (H) | $1s^1$ |
| Li | $[He]2s^1$ |
| Na | $[Ne]3s^1$ |
| K | $[Ar]4s^1$ |
| Rb | $[Kr]5s^1$ |
| Cs | $[Xe]6s^1$ |



**Halogens (F, Cl, Br, I, Group 7A/17) have a _____ valence configuration**

**How many valence $e^-$? _____**

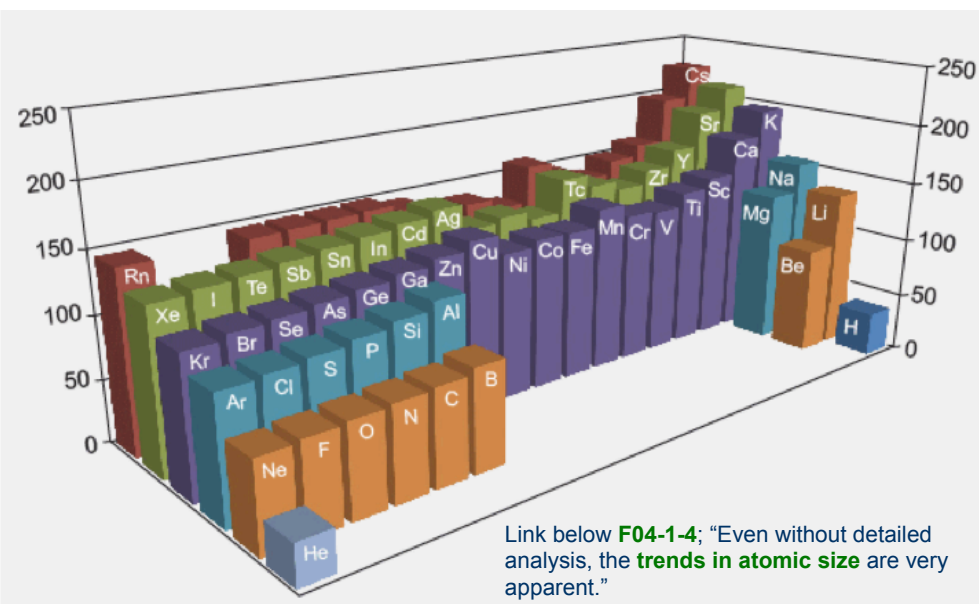
**Noble gases (He, Ar …Group 8A/18) have a _____ valence configuration**

**How many valence $e^-$? _____**

**The number of valence electrons determines the chemistry!**



# Know the Periodic Trends in Atomic Size




Link below **F04-1-4**; "Even without detailed analysis, the **trends in atomic size** are very apparent."

Which is the largest element?