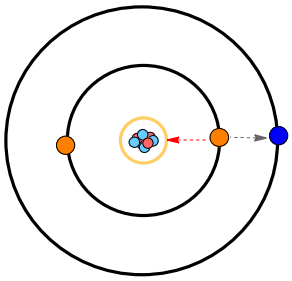
CONCEPT: PERIODIC TREND: EFFECTIVE NUCLEAR CHARGE

- Within an atom, an electron experiences attraction by the nucleus and repulsion by surrounding electrons.



□ **Effective Nuclear Charge (Z_{Eff})**: Measurement of attractive force between protons and electrons.

- ____ Z_{Eff} = ____ attractive force = electrons pulled closer to the nucleus.

□ **Shielding Constant (S)**: Measurement of repulsive force between **valence electrons** and **inner core electrons**.

- ____ S = ____ repulsive force = **valence electrons** pushed further away from the nucleus.

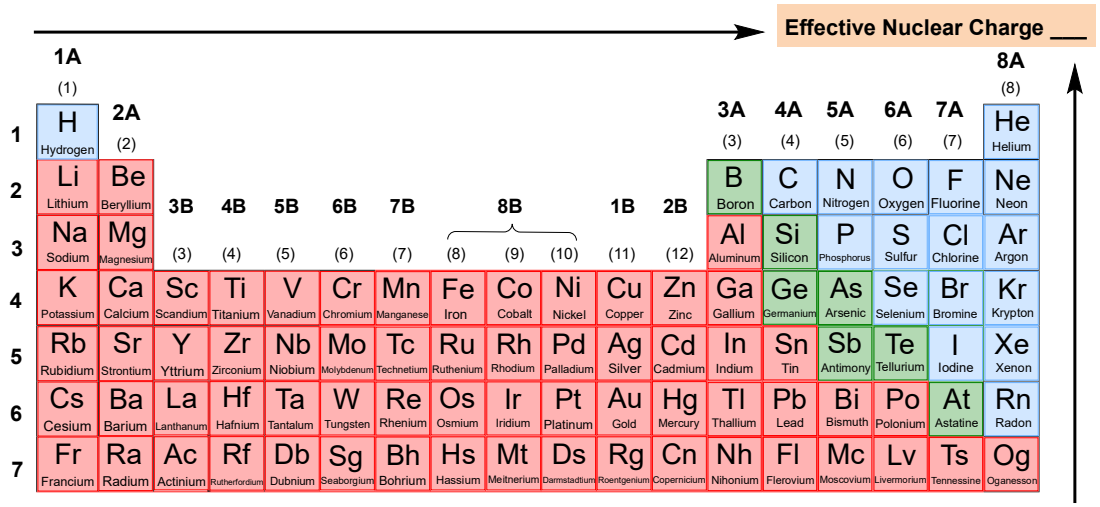
Periodic Trends

- The attractive force between electrons and the nucleus is influenced by shell number and quantity electrons.

□ ____ shell number = ____ distance between electron and nucleus = ____ attractive force.

□ ____ quantity of electrons in the same shell or subshell = ____ attractive force.

□ **Periodic Trend:** Effective nuclear charge _____ moving from left to right across a period and going up a group.



EXAMPLE: Which of the following represents a chalcogen with the greatest effective nuclear charge?

a) Cl b) Li c) S d) Te e) Ne

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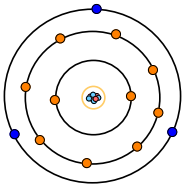
Calculate without Slater's Rules

- We take a simple approach to calculate the effective nuclear charge of a **valence electron** when only given the _____.

Effective Nuclear Charge



Al (Group 3; Z = 13)

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^1$

Effective Nuclear Charge Formula

_____ = _____ – _____

□ Z_{Eff} = Effective Nuclear Charge

□ _____ = Atomic Number

□ S = Shielding Constant (Inner Core Electrons)

EXAMPLE: What is the effective nuclear charge felt by an electron in the third shell of an aluminum atom?

STEP 1: Find the element and its atomic number on the periodic table.

STEP 2: Write its condensed electron configuration and determine its number of **inner core electrons**.

STEP 3: Use the atomic number and the shielding constant, **S**, to determine the effective nuclear charge.

PRACTICE: What is the identity of an element when the effective nuclear charge of its valence electrons is 18 while its shielding constant is 5?

a) P b) Ar c) N d) V e) Al

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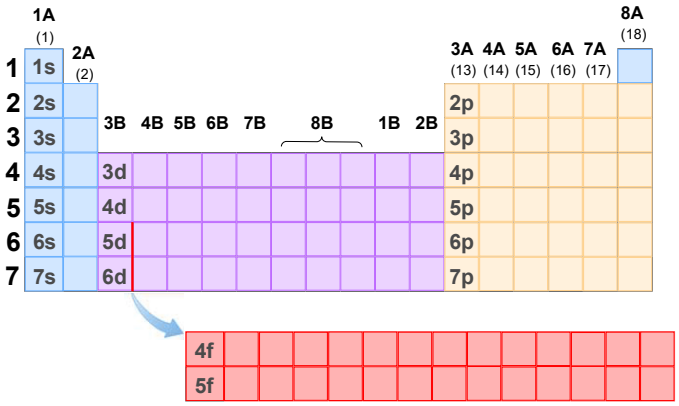
Calculate with Slater's Rules

- **Slater's Rules**: System used to determine the effective nuclear charge of a specific **electron** within an orbital.

EXAMPLE: Using Slater's Rules, calculate the effective nuclear charge of a 3p orbital electron in calcium.

STEP 1: Group electrons in an electron configuration in order of increasing *n* value and in this form:

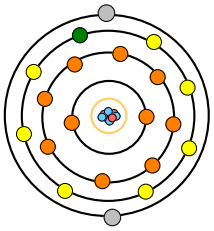
[1s] [2s,2p] [3s,3p] [3d] [4s,4p] [4d] [4f] [5s,5p] [5d]….



STEP 2: Identify an **electron** within the selected electron group.

- □ Use lower electron groups to the left to determine the calculated shielding constant, S_{Cal}.
- □ Ignore higher electron groups to the right (they don't shield).

[$1s^2$] [$2s^2$,$2p^6$] [$3s^2$, $3p^6$] [$4s^2$]



STEP 3: Use the calculated shielding constant, S_{Cal}, of the electron to determine the effective nuclear charge.

Slater's Rule

Shielding Constant Formula

S_{Cal} = [(e⁻ group)•(σ)] + Σ[(_____ e⁻ groups)•(σ)]

- □ ___σ___ = Slater's Constant
- □ ___S_{Cal}___ = Calculated Shielding Constant (Slater's Rule)

Slater's Constant Values

For *s* and *p* electrons:

1) Electrons in the same group: σ = _____.
2) Electrons in (n-1) group: σ = _____.
3) Electrons in (n-2) group: σ = _____.

For *d* and *f* electrons:

1) Electrons in the same group: σ = _____.
2) Electrons in lower groups: σ = _____.

Effective Nuclear Charge Formula

_____ = _____ – _____

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PRACTICE: In which orbital does an electron in a sulfur atom experience the greatest shielding?

a) 2p b) 2s c) 3p d) 3s e) 1s

PRACTICE: Rank the following elements by effective nuclear charge, Z_{Eff}, for a valence electron: Kr, Se, Ca, K, Ge

PRACTICE: Using Slater's Rules calculate the effective nuclear charge of the 4d orbital electron in iodine.