

CHEM 101

## Periodic Properties of the Elements



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Notes by: Jahvea Marston

University at Buffalo

**Periodic Trends:** reoccurring patterns in a column (group) or row (period)  
- Valence (e-) and their attraction

**Effective Nuclear Charge** - increases across a Period/Group

Electrons are both attracted to the nucleus and repelled by other (e-).  
-The forces of an e- experiences depend on both factors.  
• Core e- screen/shield (S) the nucleus.

The effective nuclear charge, **Z<sub>eff</sub>** is found:

$$Z_{\text{eff}} = Z - S$$

Z = atomic number (# Protons)

S = screening constant (# of Core e-)

Though in simple terms the value of the screening constant (S) is the number of Core electrons there are a set of rules that are described in the following equation:

$$S = 1.35 \times (\# \text{ e- when } (e-)-1)]^* + 1.85 \times (\# \text{ e- when } n-1)]^* + [1 \times \# \text{ e- when } (n-2) \text{ or } (n-1)]^*$$

\*:

- For the ns, np, nd and nf sub-shells (with the exception of the 1s sub-shell which would be .30) the outer-most sub-shell or the last sub-shell in an electron configuration will have one electron taken away and the number of electrons left will be the number multiplied by .35. Note: if there are no electrons left then that number would equal to 0.
- For ONLY the ns and np sub-shells to calculate the number that is multiplied by .85 the number of electrons (all of them) in the sub-shell before the highest one are added. If the Z<sub>eff</sub> of a nd or nf sub-shell needs to be found this portion would be omitted.
- This rule is similar to the previous one, though there are exceptions. The concept of adding all of the electrons is the same. For the ns, np sub-shells go two sub-shells lower and add the electrons (n-2). For the nd, nf go one sub-shell lower and add the electrons (n-1). If there are no electrons or if the configuration is too short to fit the rule (such as oxygen: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>4</sup> the number to be multiplied by 1 would be 0 because there are no more sub-shells) the number to be multiplied would be 0.

Effective nuclear charge is a periodic property:

- If increases across a period
- If increases slightly down a group

## Chapter 7

### Increases across a Period

The number of core e<sup>-</sup> that shield outer-shell e<sup>-</sup> from the nucleus stays constant, but the charge on the nucleus (Z) increases.



$$Z_{\text{eff}} = 3 - 2 = 1$$

### Increases across a Group

The core e<sup>-</sup> cloud is more diffuse and less effective to screen.

## **Periodic Trends**

- Sizes of Atoms and Ions
- Ionization energy, IE
- Electron affinity, EA

When making predictions, consider:

- Energy level (n) of valence e<sup>-</sup>
- Z<sub>eff</sub> strength

## **Size of an Atom**

The nonbonding atomic radius or van der Waals radius is half of the shortest distance separating two nuclei during a collision of atoms.

The bonding atomic radius is half the inter-nuclear distance when atoms are bonded.

$$\text{-Bonding atomic radius} = 1/2d$$

The bonding atomic radius tends to:

- decrease from left to right across a period due to increasing Z<sub>eff</sub>
- increase from top to bottom of a group due to increasing values of n.

He is the smallest

Fe is the largest