

Ch 7: Periodic Properties of Elements

1) Development of the Periodic Table

A. developed at the same time (but separately) in 1869 by

- Lothar Meyer

- Dmitri Mendeleev - credited as "Father of the Periodic Table" because he was more vocal about it.

- PT arranged in order of increasing atomic mass & similarities in properties of elements.

(Z)

B. Henry Moseley (1913) - came up w/ the idea of atomic number.

Rearranged the P.T. in order of increasing atomic number, fixed anomalies in Mendeleev's table

(ex. Ar (18) weighs more than K (19))

2) Effective Nuclear Charge - how much attraction an electron feels for the nucleus

A. many properties of elements depend upon an atom's e⁻ configuration & how strongly it's attracted to the nucleus. Remember Coulomb's Law

$$F = \frac{kQ_1Q_2}{d^2}$$

B. In atoms w/ more than one e⁻, that e⁻ is both attracted to the nucleus & repelled by all the other e⁻'s in the atom.

1) Effective Nuclear Charge (Z_{eff})

- charge felt by an e⁻, from the nucleus minus the average repulsion felt by all the other e⁻'s.

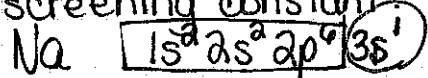
$$Z_{\text{eff}} = Z - S$$

Z (atomic #)

S (screening constant)

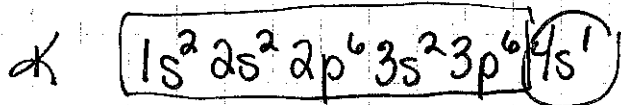
- screening constant (S) - usually close to the # core e⁻ in the atom

Ex) Detailed calculations show that the value of Z_{eff} for Na & K atoms is $(2.51+)$ and $(3.49+)$, respectively. What value do you estimate for Z_{eff} experienced by the outer most e^- in both Na & K by assuming core e^- contribute 1.00 and valence e^- contribute 0 to the screening constant?



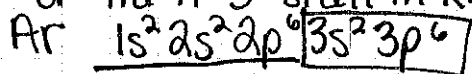
$$Z_{eff} = Z - S$$

$$= 11 - 10 = +1$$

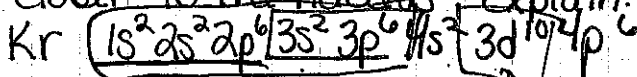


$$Z_{eff} = 19 - 18 = +1$$

Ex) Which will experience greater Z_{eff} , the e^- in the $n=3$ shell of Ar or the $n=3$ shell in Kr? Which is closer to the nucleus? Explain.



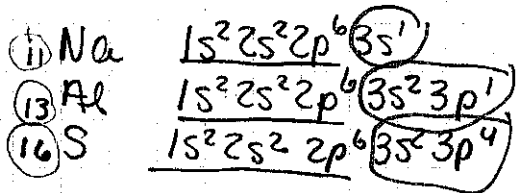
$$Z_{eff} = 18 - 10 = +8$$



$$Z_{eff} = 36 - 10 = +26$$

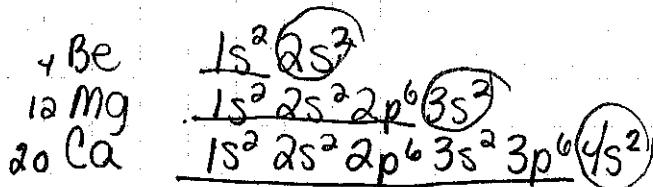
c. Trends in Z_{eff} on the Periodic Table

1) Across a period (row) - Z_{eff} increases. Why?



Z (Atomic #) increases
 S - no changes

2) Down a group (column) - Z_{eff} increases why?



Z increase
 S does increase but not as much as Z does

3i

$$\boxed{1s^2 2s^2 2p^6} \boxed{3s^2 3p^2}$$

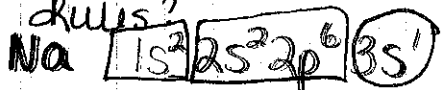
$$Z_{\text{eff}} = 14 - [(3 \times 0.35) + (8 \times 0.85) + (2 \times 1.00)] =$$

$$14 - 9.85 = 4.15$$

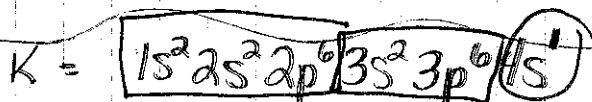
3) Slater's Rules for Z_{eff} - limit to elements w/o d or f subshells (rules are too complicated \uparrow)

- A) e^- in an energy level higher than the e^- of interest do NOT contribute anything to the screening constant (S).
- B) e^- in the same energy level as the e^- of interest - contribute .35 to S. (remember you are one of these e^- so subtract yourself)
- C) e^- in the energy level directly below the e^- of interest - contribute .85 to S.
- D) e^- closer to the nucleus - contribute 1.00 to S.

ex) Detailed calculations show that Z_{eff} for Na and K are 2.51+ and 3.49+, respectively. What are the values for Z_{eff} using Slater's rules?

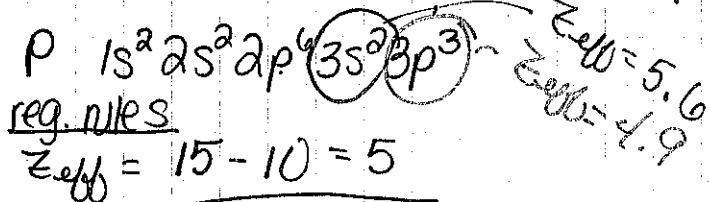


$$Z_{eff} = 11 - [(0 \cdot 35) + (8 \cdot 85) + (2 \cdot 1.00)] = 11 - 8.8 = 2.2$$



$$Z_{eff} = 19 - [(0 \cdot 35) + (8 \cdot 85) + (10 \cdot 1.00)] = 19 - 16.8 = 2.2$$

ex) if the core e^- were totally effective at shielding the valence e^- and the valence e^- provided no shielding for each other, what would be Z_{eff} for the 3s and 3p e^- in P? Repeat the calculations using Slater's Rules. Detailed calculations say Z_{eff} for the 3s e^- is 5.6+ and 4.9+ for the 3p e^- . Why is Z_{eff} different for 3s e^- than 3p e^- ? If you remove an e^- from P, which orbital will it come from? 3p



reg. rules

$$Z_{eff} = 15 - 10 = 5$$

Slater's

$$Z_{eff} = 15 - [(4 \cdot 35) + (8 \cdot 85) + (2 \cdot 1.00)]$$

$$Z_{eff} = 15 - 10.2 = 4.8$$

\uparrow 3s e^- are closer to the nucleus than the 3p e^-

