CHEM 103

Explaining Periodic Trends

Lecture Notes
April 13, 2006
Prof. Sevian

Please sit with your groups today.
We will be doing a group problem
at the end of class.

Announcements

- Lab week change

  Due to Chancellor's Inauguration Week activities, classes on the afternoon of April 26 are cancelled, so we have to move the lab that day to one week earlier. Since we are having Exam 3 on April 27, it makes sense to move all the labs that week to one week earlier.

  Summary: Lab 9 will happen the week of April 17. There will be no labs the week of April 24. This is a shift to one week earlier for everyone.

Agenda

- Interpreting measured properties of elements in light of their electronic configurations
  - Ionization energy
  - Other properties…
- Group problem

Example: Sodium Atom

A neutral sodium atom has 11 protons and 11 electrons

Electronic configuration is $1s^2\ 2s^2\ 2p^6\ 3s^1$

(Note: not drawn to scale!)

Book calls this Z_{eff}

CORE
Net +1 charge

11 protons and some neutrons (charge: +11)

All complete inner shells of electrons (charge: -10)

VALENCE SHELL
Net -1 charge

Outer electrons beyond all complete inner shells (charge: -1)

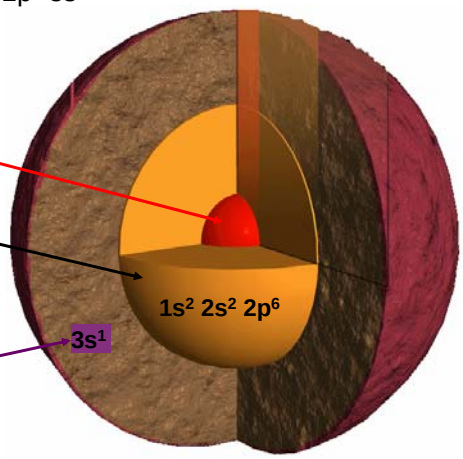


Image modified from
http://www.badastronomy.com/bad/movies/thecore_review.html

Example 2: Magnesium Atom

A neutral magnesium atom has 12 protons and 12 electrons

Electronic configuration is $1s^2\ 2s^2\ 2p^6\ 3s^2$

(Note: not drawn to scale!)

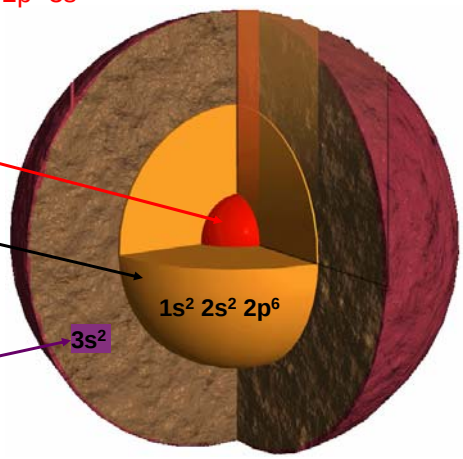
CORE
Net +2 charge

12 protons and some neutrons (charge: +12)

All complete inner shells of electrons (charge: -10)

VALENCE SHELL
Net -2 charge

Outer electrons beyond all complete inner shells (charge: -2)



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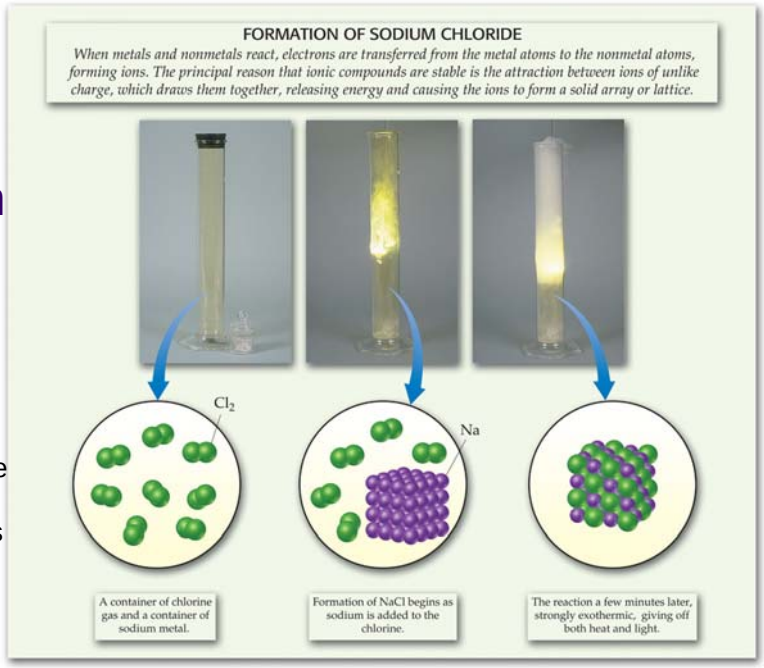
Core vs. Valence

An abbreviated periodic table (showing only the s- and p-blocks)

H +1C, -1V						He +2C, -2V
Li +1C, -1V	Be +2C, -2V	B +3C, -3V	C +4C, -4V	N +5C, -5V	O +6C, -6V	F +7C, -7V	Ne +8C, -8V
Na +1C, -1V	Mg +2C, -2V	Al +3C, -3V	Si	P	S	Cl	Ar +8C, -8V
K	Ca	Ga	Ge	As	Se	Br	Kr

Lattice energy is formation energy

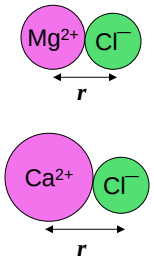
Equal and opposite to energy required to break apart the lattice into separated ions



Lattice Energy

The energy associated with forming an ionic crystal from atoms

Why does magnesium chloride ($MgCl_2$) have a larger lattice energy than calcium chloride ($CaCl_2$)?



$MgCl_2$ has a larger lattice energy than $CaCl_2$

More energy is required to disrupt the $MgCl_2$ lattice

Ionic bonding is stronger in $MgCl_2$ than in $CaCl_2$

Cl^- ions get closer to the center of positive charge (core) in $MgCl_2$ than in $CaCl_2$

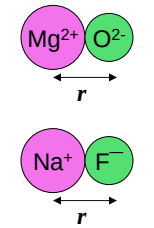
Mg^{2+} cations have smaller radius than Ca^{2+} cations

Magnesium is in period 3
Calcium is in period 4

Lattice Energy

The energy associated with forming an ionic crystal from atoms

Why does magnesium oxide (MgO) have a larger magnitude by a factor of 4 (more negative) lattice energy than sodium fluoride (NaF)?



MgO has a 4x larger magnitude lattice energy than NaF

Four times more energy is required to disrupt the MgO lattice

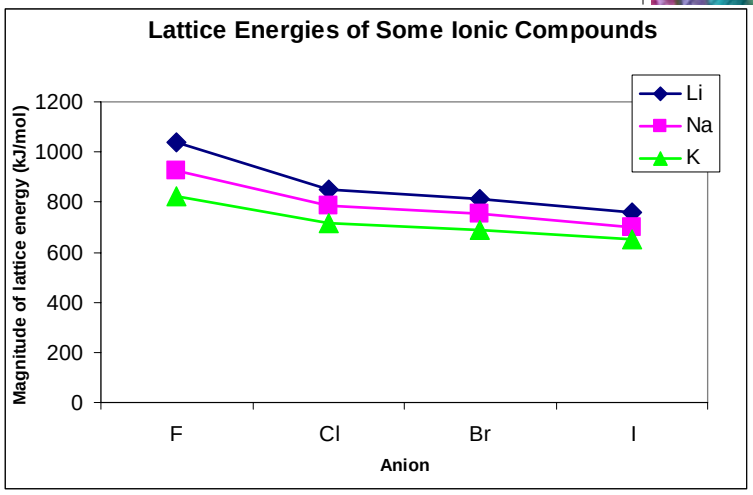
Ionic bonding is 4 times stronger in MgO than in NaF

Inter-ion distances are approximately the same in both lattices, but both charges are doubled in MgO compared to NaF

Mg^{2+} and O^{2-} ions have +2 and -2 charges, respectively
Na^+ and F^- ions have +1 and -1 charges, respectively

Magnesium and Sodium are both in period 3
Oxygen and Fluorine are both in period 2

Period and Group Trends in Lattice Energy



Data from textbook p. 305