

PERIODIC TRENDS

- Some properties of elements can be related to their positions on the periodic table.

ATOMIC RADIUS

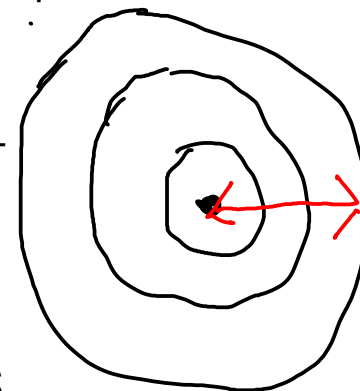
- The distance between the nucleus of the atoms and the outermost shell of the electron cloud.

- Relates to the size of the atom.

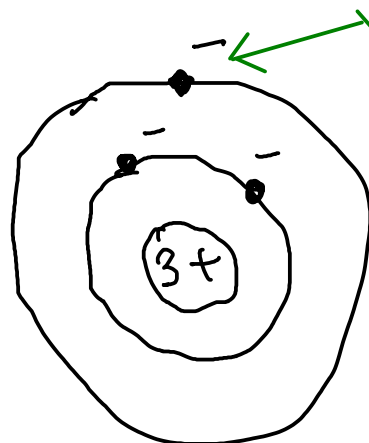
- As you go DOWN A GROUP (↓), the atomic radius INCREASES.

- Why? As you go down a period, you are ADDING SHELLS!

- As you go ACROSS A PERIOD (→), the atomic radius DECREASES

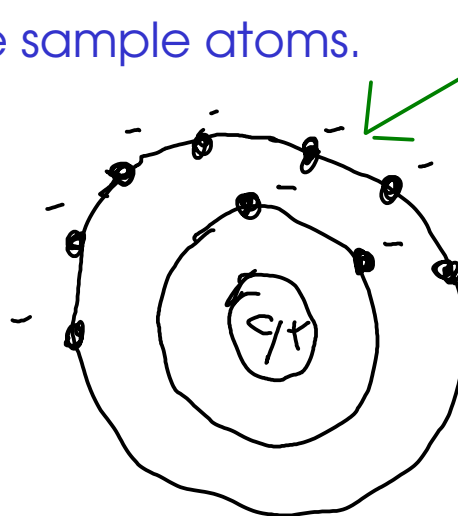


Why? Let's look at some sample atoms.



lithium $1s^2 2s^1$

Outer electron sees an effective +1 charge (shielded from +3 nucleus by 2 electrons)



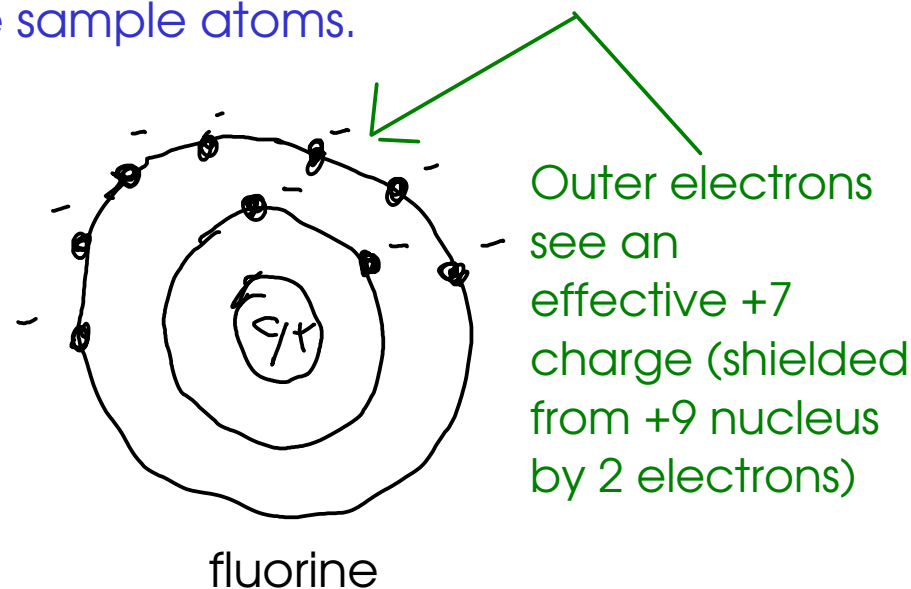
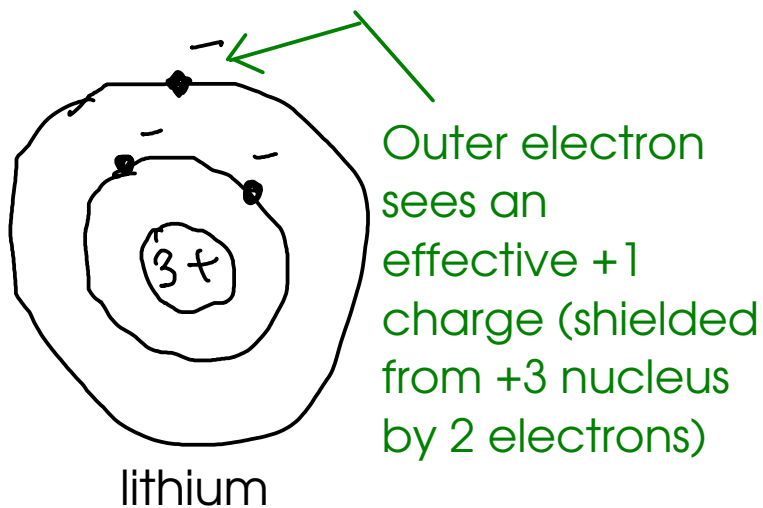
fluorine $1s^2 2s^2 2p^5$

Outer electrons see an effective +7 charge (shielded from +9 nucleus by 2 electrons)

... so fluorine's outer shell is pulled closer to the nucleus than lithium's!

(FIRST) IONIZATION ENERGY

- The amount of energy required to remove a single electron from the outer shell of an atom.
- Relates to reactivity for metals. The easier it is to remove an electron, the more reactive the metal.
- As you go DOWN A GROUP (↓), the ionization energy DECREASES.
 - Why? As you go down a period, you are ADDING SHELLS. Since the outer electrons are farther from the nucleus and charge attraction lessens with distance, this makes electrons easier to remove as the atoms get bigger!
- As you go ACROSS A PERIOD (→), the ionization energy INCREASES.
 - Why? Let's look at some sample atoms.



... since fluorine's outer electrons are held on by a larger effective charge, they are more difficult to remove than lithium's.

THE FIRST TWO PERIODIC TRENDS IN A NUTSHELL

LARGER
IONIZATION
ENERGYSMALLER
RADIUS

IA H	IIA Be																		VIIIA He
Li	Be											III A B	IV A C	V A N	VIA O	VII A F			Ne
Na	Mg	IIIB	IVB	VB	VIB	VII B	VIII B	IB	IIB			Al	Si	P	S	Cl			Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br			Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I			Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At			Rn
Fr	Ra	Ac*	Rf	Db	Sg	Bh	Hs	Mt	*"inner" transition metals go here										

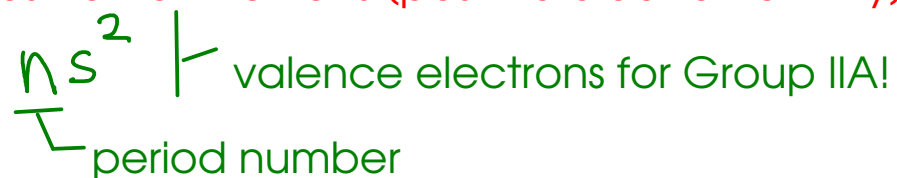
LARGER
RADIUSSMALLER
IONIZATION
ENERGY

190 ELECTRON AFFINITY

- the electron affinity is the ENERGY CHANGE on adding a single electron to an atom.
 - Atoms with a positive electron affinity cannot form anions.
 - The more negative the electron affinity, the more stable the anion formed!
- General trend: As you move to the right on the periodic table, the electron affinity becomes more negative.

EXCEPTIONS

- Group IIA does not form anions (positive electron affinity)!



- To add an electron, the atom must put it into a higher-energy (p) subshell.

- Group VA: can form anions, but has a more POSITIVE electron affinity than IVA



- $\underbrace{\hspace{1.5cm}}$ Half-full "p" subshell! To add an electron, must start pairing!

- Group VIIIA (noble gases) does not form anions



"MAIN" or "REPRESENTATIVE" GROUPS OF THE PERIODIC TABLE

	IA		IIA
1	H		
2	Li		Be
3	Na		Mg
4	K		Ca
5	Rb		Sr
6	Cs		Ba
7	Fr		Ra

Alkali metals

Alkaline earth metals

Read about these in Section 8.7 of the Ebbing textbook!

						VIIIA
IIIA	IVA	VA	VIA	VIIA		He
B	C	N	O	F		Ne
Al	Si	P	S	Cl		Ar
Ga	Ge	As	Se	Br		Kr
In	Sn	Sb	Te	I		Xe
Tl	Pb	Bi	Po	At		Rn

Chalcogens

Halogens

Noble/Inert gases

The representative (main) groups

GROUP IA - the alkali metals

valence electrons:



- React with water to form HYDROXIDES



alkali metals form BASES when
put into water!

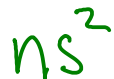
- Alkali metal OXIDES also form bases when put into water. (This is related to METALLIC character. The more metallic something is, the more basic its oxide. Nonmetals have ACIDIC oxides!)



- Physical properties: All of these elements are soft metals with relatively low melting points.

GROUP IIA - the alkaline earth metals

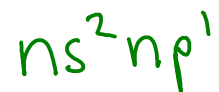
valence electrons:



- May react with water in a reaction similar to the alkali metals, producing hydroxides and hydrogen gas. For some of the alkaline earth metals, this reaction takes place at a significant rate only at high temperatures..
- Form basic oxides, formula: M_2O
- These elements are soft and low-melting ... but harder and higher melting than alkali metals.
- The name "alkaline earth" comes from the observation that the "earths" (oxides) of these metals are basic.

GROUP IIIA

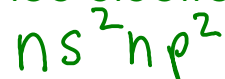
valence electrons:



- most of the elements in this group are metals, but there is also a semiconductor (boron).
- The oxides of these elements are of the form M_2O_3
 - oxides of boron are acidic (metalloids tend to behave more like nonmetals in the acidity of their oxides).
 - Aluminum and gallium have AMPHOTERIC oxides (react as acids or bases), and the larger Group IIIA oxides are basic
- These elements do not react directly with water to make hydroxides, unlike Groups IA and IIA.

GROUP IVA

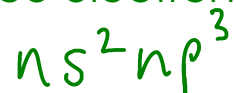
valence electrons



- contains some elements of each type: nonmetal, metalloid, and metal.
- oxides range from acidic to amphoteric, with formulas MO_2 or MO (C, Pb form both!)
- don't react with water to make hydroxides

GROUP VA

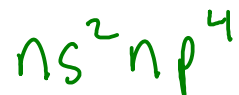
valence electrons



- range from nonmetal to metallic, but with only one metal (bismuth).
- Oxides of group VA nonmetals are acidic, while the group VA metalloids have amphoteric oxides. Bismuth's oxide is basic
- Formulas of these oxides vary considerably, but the most common variants are: RO_2, RO_3

GROUP VIA - the chalcogens

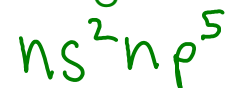
valence electrons



- Like Group VA, formulas of oxides of these elements vary. Common ones are: RO_2, RO_3
- mostly nonmetals/metalloids, plus one metal (polonium). Oxides range from acidic to amphoteric.
- This group's name means - "ore producers" Many metal ores contain oxygen and/or sulfur!

GROUP VIIA - the halogens

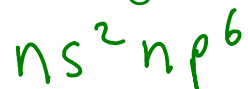
electron configuration:



- react with water, but form ACIDS when they do so! (ex: chlorine and water make HCl and HOCl).
- Oxides of the halogens are not very stable, but they are acidic.
- nonmetals, exist primarily as DIATOMIC MOLECULES.
- halogens are very similar in their chemical reactions, even though their physical appearance varies considerably!
- This group's name means "salt formers" (think sodium chloride)

GROUP VIIIA - the noble or inert gases

electron configuration:



- characterized by their lack of chemical reactivity. The lighter noble gases have no known compounds, while the heavier ones sometimes form molecules with reactive elements like oxygen and fluorine.
- exist primarily as single (uncombined) atoms - NOT diatomic molecules like the halogens.

CHEMICAL BONDS

- A CHEMICAL BOND is a strong attractive force between the atoms in a compound.

3 TYPES OF CHEMICAL BOND

Type	Held together by...	Example
Ionic bonds	attractive forces between oppositely charged ions	sodium chloride
<u>Covalent</u> bonds	sharing of valence electrons between two atoms (sometimes more - "delocalized bonds")	water
* Metallic bonds	sharing of valence electrons with all atoms in the metal's structure - make the metal conduct electricity	any metal

*For CHM 110, you don't need to know anything more about metallic bonds than what's in this table. If you take physics, you may learn more about the characteristics of the metallic bond.

... so how can you tell what kind of bond you have? You can use the traditional rules of thumb:

- Metal-Nonmetal bonds will be ionic
 - Nonmetal-nonmetal bonds are usually covalent
- Metalloids act like NONMETALS, here.

... but for better information about bonding, you can use ELECTRONEGATIVITY.

ELECTRONEGATIVITY:

-A measure of how closely to itself an atom will hold shared electrons

p346:
chart of
electroneg.
values

p352,
10th

... in other words, how ELECTRON-GREEDY an atom is!

Bonds with ...	are ...	Examples
Little or no difference in electronegativity between atoms	NONPOLAR COVALENT	C-C, C-H, etc.
Larger differences in electronegativity between atoms	* POLAR COVALENT	H-F, C-F, C-Cl, etc.
Very large differences in electronegativity between atoms	IONIC	NaCl, KBr, etc.

* A POLAR bond is a bond where electrons are shared unevenly - electrons spend more time around one atom than another, resulting in a bond with slightly charged ends