

Periodicity

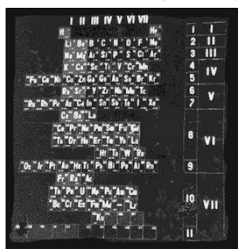
Dr. Ron Rusay

• 7. Atomic Structure and Periodicity

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Periodic Table

- Mendeleev's Table 1868-1871
Mural at St. Petersburg University, Russia



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The Modern Periodic Table

Legend:

- Main Group Elements:
 - Metals (main-group)
 - Metals (transition)
 - Metals (inner transition)
 - Nonmetals
 - Metalloids
- Transition Elements
- Inner Transition Elements:
 - Lanthanides
 - Actinides

Periodic Properties



Calibrated Peer Review Writing Assignment

Chemical Bonds

Definition:
Attractive forces which hold atoms together and provide a particular molecular arrangement of atoms with new chemical properties.

Electron Configurations & Bonds

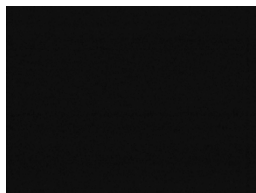
Noble Gases and The Rule of Eight

- δ When two nonmetals react to form a covalent bond: They share electrons to achieve a Noble gas electron configuration.
- δ When a nonmetal and a metal react to form an ionic compound: Valence electrons of the metal are lost and the nonmetal gains these electrons.

Ionic Bonds

- α Result from electrostatic attractions of closely packed, oppositely charged ions.
- α Form when an atom which can easily lose electrons reacts with one which has a high electron affinity, that is, it can easily gain electrons.
- α Eg. Mg and Cl; K and O

Ionic vs. Covalent Bonding

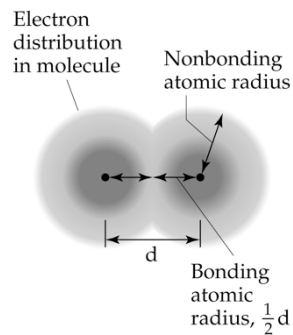
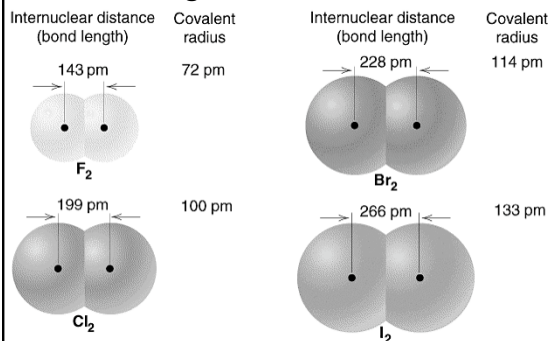


Bond Length

(Covalent Bonds)

- δ Interatomic distance.
- δ It is the distance where the bond energy is at a minimum value, and which is the most stable atomic form.

Bond Lengths and Covalent Radius

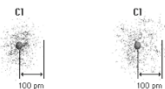


Periodic Trends

Atomic Radius

Atomic Radii:

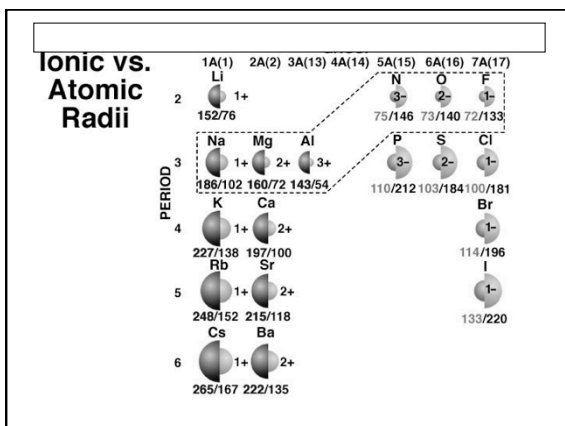
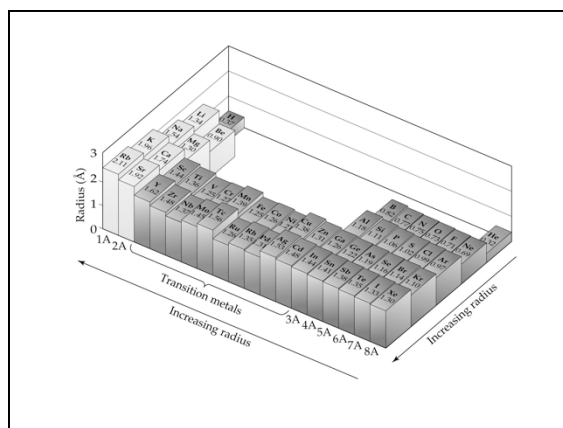
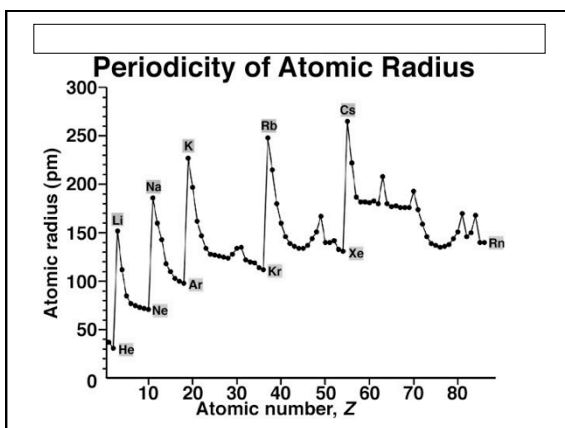
What's a picometer?
 $1 \times 10^{-12} \text{ m}$



- decreases going from left to right across a period;
- increases going down a group.

Atomic Radii

Periodic Trends:
Atomic Radii



QUESTION

Which of the following has the smallest radius?

- A) F
- B) Ne
- C) O^{2-}
- D) Mg^{2+}
- E) Na

Ionization Energy

Ionization Energy

QUESTION

The first ionization energy of Mg is 735 kJ/mol.
The second ionization energy is:

- A) 735 kJ/mol.
- B) less than 735 kJ/mol.
- C) greater than 735 kJ/mol.
- D) More information is needed to answer this question.
- E) none of these.

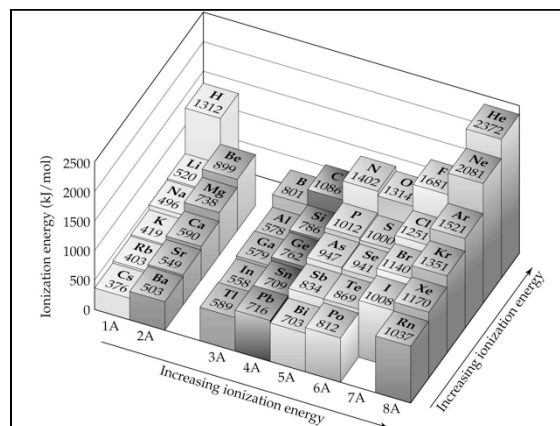
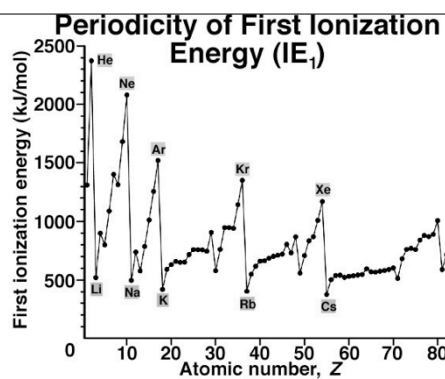
Periodic Trends

- ∂ First ionization energy:
- ∂ increases from left to right across a Period;
- ∂ decreases going down a Group.

QUESTION

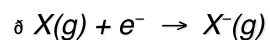
Choose the element with the highest IE.

- A) Na
- B) Mg
- C) Al
- D) Si
- E) S

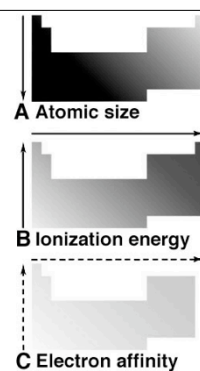


Electron Affinity

δ The energy change associated with the addition of an electron to a gaseous atom.



Trends in Three Atomic Properties

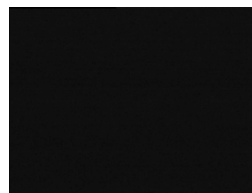


Electronegativity

δ The ability of an atom in a molecule to attract shared electrons to itself.

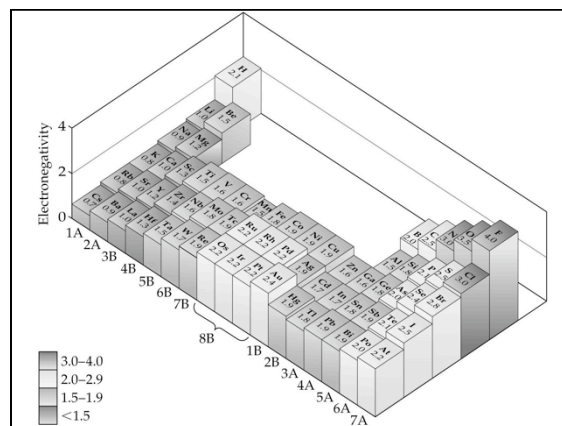
$$\delta \Delta = (H-X)_{actual} - (H-X)_{expected}$$

Electronegativity



Electronegativity

Periodic Trends:
Electronegativity



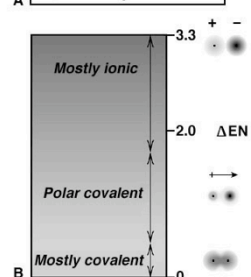
QUESTION

For the elements Rb, F, and O, the order of increasing electronegativity is:

- A) Rb < F < O.
- B) Rb < O < F.
- C) O < F < Rb.
- D) F < Rb < O.
- E) none of these.

Boundary Ranges for Classifying Ionic Character of Chemical Bonds

ΔEN	IONIC CHARACTER
>1.7	Mostly ionic
0.4-1.7	Polar covalent
<0.4	Mostly covalent
0	Nonpolar covalent



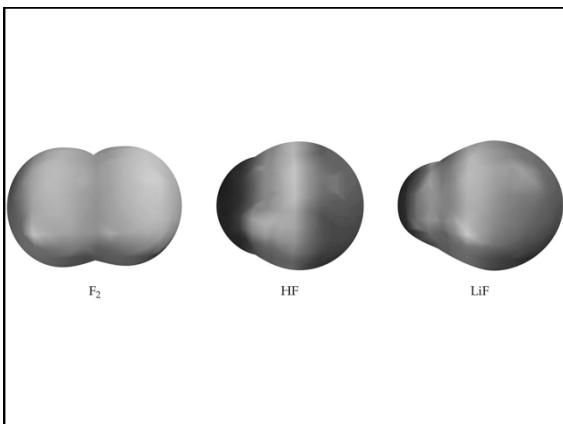
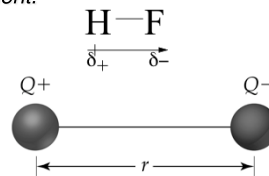
QUESTION

Atoms having greatly differing electronegativities are expected to form:

- A) no bonds.
- B) polar covalent bonds.
- C) nonpolar covalent bonds.
- D) ionic bonds.
- E) covalent bonds.

Covalent Bond Polarity

A molecule, such as HF, that has a center of positive charge and a center of negative charge is said to be polar, or to have a dipole moment.



QUESTION

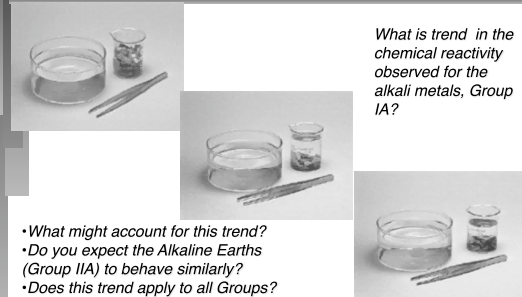
Choose the compound with the most ionic bond.

- A) LiCl
- B) KF
- C) NaCl
- D) LiF
- E) KCl

Element	Electron Configuration	Melting Point (°C)	Density	Atomic Radius (Å)	I_1 (kJ/mol)
Fluorine	[He]2s ² 2p ⁵	-220	1.69 g/L	0.71	1681
Chlorine	[Ne]3s ² 3p ⁵	-102	3.21 g/L	0.99	1251
Bromine	[Ar]3d ¹⁰ 4s ² 4p ⁵	-7.3	3.12 g/cm ³	1.14	1140
Iodine	[Kr]4d ¹⁰ 5s ² 5p ⁵	114	4.93 g/cm ³	1.33	1008

Trends in Reactivity

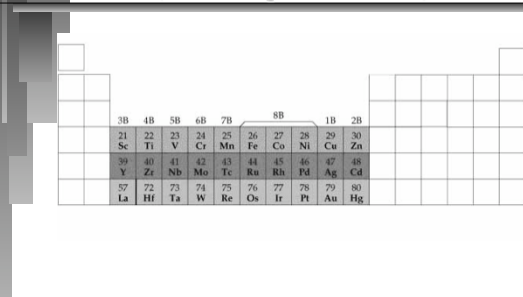
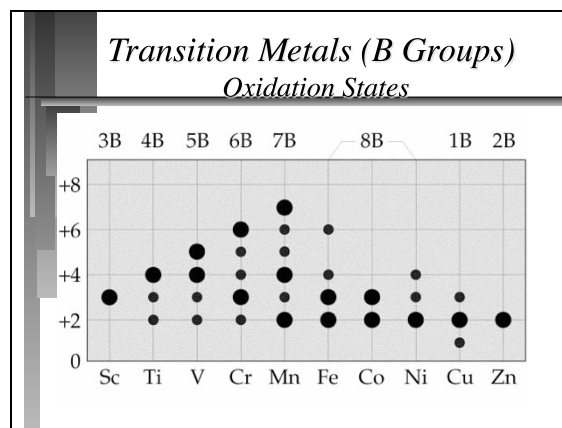
Lithium (Li), Sodium (Na) & Potassium (K)



What is trend in the chemical reactivity observed for the alkali metals, Group IA?

- What might account for this trend?
- Do you expect the Alkaline Earths (Group IIA) to behave similarly?
- Does this trend apply to all Groups?

Transition Metals (B Group Elements)

Information & the Periodic Table

A great deal of specific, general and comparative information can be developed from the Periodic Table:

1. Group valence electron configurations.
2. Individual electron configurations.
3. General chemical behavior and physical properties.
4. Distinguishing metals and nonmetals.

Summary of Periodic Trends

Periods (Horizontal Rows)

- **Atomic size** generally decreases across a Period.
- The **first ionization energy** and **electronegativity** generally increase across a Period.

This is a result of **increasing effective nuclear charge** and electrons being in the **same principal energy level**.

Summary of Periodic Trends
Periods (Horizontal Rows)

- δ *Metallic character decreases as elements change from metals to metalloids to nonmetals.*
- δ *General reactivity is highest at the left and right ends of a Period. (Excluding the inert noble gases.)*
- δ *In Period 2, the physical properties change abruptly between carbon (solid) and nitrogen (gas).*