Periodic Trends

In this exercise, the concepts of atomic radius, ionization energy, electron affinity, physical properties for the elements in the periodic table their chemical reactivity characteristics within a given family will be investigated. Your understanding of the periodicity of the elements will enable you—and chemists—to predict the outcomes for the behavior of atoms.

Part 1 Physical Periodicity & Characteristics

A. Atomic Radii (within families). The atomic radium is defined as half the distance between the nuclei of two atoms of the same element that are bonded together. In general, it is more difficult to remove electrons from atoms with small atomic radii. Is there any periodicity of atomic radii within families? By graphical analysis of empirical data, you should look for trends in specific data and try to develop reasons for the any observed trends. The next page has two graphs:

a. A plot atomic radii versus atomic number for the first half of the periodic table is given.
b. Write the correct elemental symbol onto the circle.
c. Identify the following families below and assign each family a different color of your choice

Group I alkali metals;	Group IV carbon family;	Group VI chalogens;
Group II alkaline earth metals;	(exclude Group V)	Group VII halogens;
Group III boron family;		Group VIII noble gases

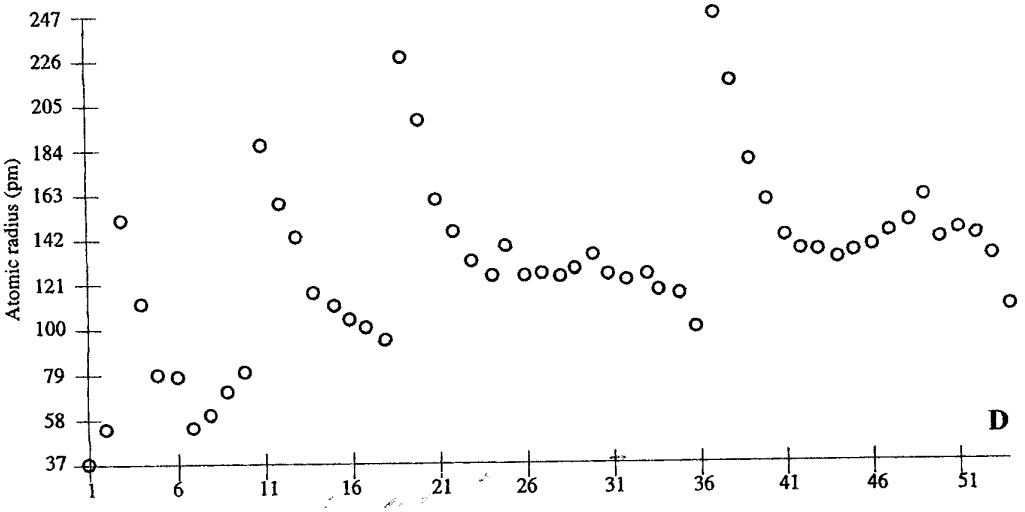
d. Color the elements within a periodic family the assigned color.
e. Connect the same color circles for a given family by connecting those circles with a thin straight line. Label this line with the corresponding family name.
f. Connect all circles by increasing atomic number with a thin straight line.

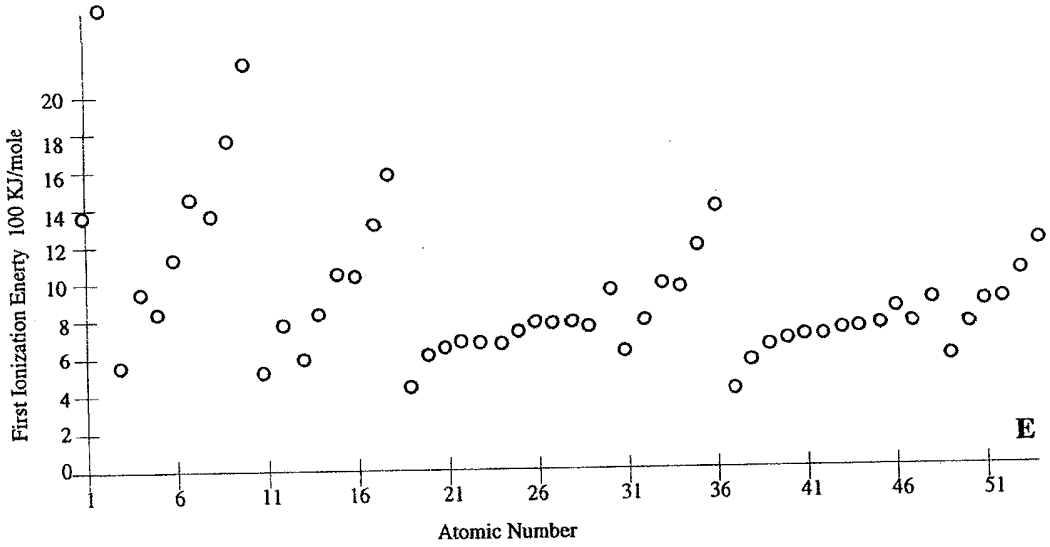
B. First Ionization Energy (generating plasma). The endothermic energy required to completely remove one valence electron from an atom in the gas phase $A(g) \text{ ------> } A^{+}(g) + 1e^{-}$

a. A plot first ionization energy versus increasing atomic number for the first half of the periodic table is given
b. Write the correct elemental symbol onto the circle.
c. Identify the following families below and assign each family a color as in part A above.

Group I alkali metals;	(exclude Group V)	Group VI chalogens;
(exclude Group II)	Group V nitrogen;	Group VII halogens;
Group III boron family;		Group VIII noble gases

d. Color the elements within a periodic family the assigned color.
e. Connect the same color circles for a given family by connecting those circles with a thin straight line. Label this line with the corresponding family name.
f. Connect all circles by increasing atomic number with a thin straight line.





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Electron Affinities (kJ/mol)

-77																	21
-58	241											-23	-123	0	-141	-322	29
-53	230											-44	-120	-74	-200	-349	35
-48	154											-36	-116	-77	-195	-325	39
-47	120											-34	-121	-101	-190	-295	41
-45	52											-50	-101	-101	-170	-270	41
-44																	

Part 1 Questions

1) Which family has the largest atomic radii?

2) Which family has the smallest atomic radii?

3) Is there any periodicity of atomic radii within families? Explain

4) Is there any periodicity of atomic radii within periods (row)? Explain

5) In general, what happens to atomic radius as you proceed through a period (row) from the alkali metals to the noble gases?

6) How does increasing nuclear charge, Z, affect atomic radii for atoms within a period (row)? In other words, how might an attractive force between the nucleus (contains protons) and electrons affect atomic size within a period (row)?

7) How does atomic size relate to location in the periodic table?

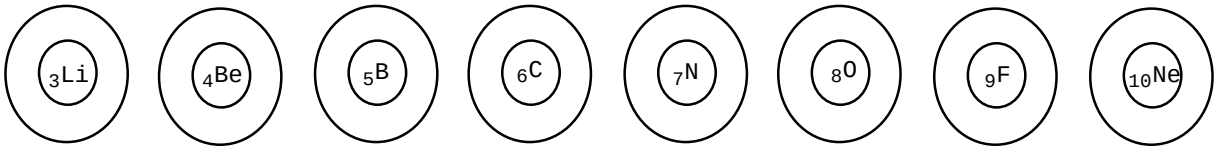
8) Does the family with the lowest with the lowest first ionization energy have a relatively large or small atomic radii?

9) Which families have the highest first ionization energies? Is there any relationship between their ionization energies and their radii? Explain using complete sentences.

Part 2 Chemical Periodicity

A. Valence electrons - Valence (outermost) electrons are in the principle energy shell furthest from the nucleus (the highest energy shell).

a. Draw Bohr electron dot structures for the elements of period (row) 2.

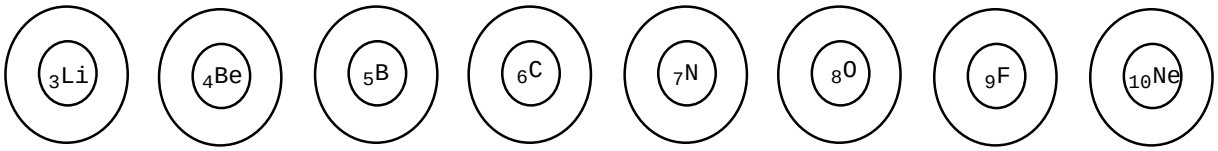


b. Draw Lewis electron dot structures or the elements of period (row) 2.

Li Be B C N O F Ne

B. General Chemical Reactivity - The reactivity of an element is related to the tendency to lose or gain electrons; that is to be oxidized (OIL) or reduced (RIG). The chemistry of metals and nonmetals are important to chemists. Metals tend to lose electrons to form positively charged cations, while nonmetals tend to gain electrons to from negatively charged anions.

a. Draw Bohr electron dot structures for the ions of period (row) 2.



Li^{+} Be^{2+} B^{3+} C^{4-} N^{3-} O^{2-} F^{1-} Ne^{0}

b. Draw Lewis electron dot structures or the ions of period (row) 2.

Li^{+} Be^{2+} B^{3+} C^{4-} N^{3-} O^{2-} F^{1-} Ne^{0}

Part 2 Questions

1) Which elements in period (row) 2 like to be oxidized to a noble gas electron configuration? These ions are isoelectronic with which noble gas?

2) Which elements in period (row) 2 like to be reduced to a noble gas electron configuration? These ions are isoelectronic with which noble gas?

3) How are metals and nonmetals grouped in the periodic table?

4) Are all elements metals or nonmetals?

5) How does the ionization energy of an atom relate to the location in the periodic table?

Part 3 Laboratory Experimentation Observations (Circle the right words)

A. Group IV - Elements

1) In general, the melting point (*increases, decreases, remains the same*) with increasing atomic number
2) In general, the boiling point (*increases, decreases, remains the same*) with increasing atomic number
3) In general, the density (*increases, decreases, remains the same*) with increasing atomic number
4) In laboratory, the melting point and boiling point data taken from the periodic table was given in (*degree Fahrenheit, degree Celsius, Kelvin*).
5) Kelvin temperature has the formula:

(K = 273 + °C K = °C - 273 ·C = 273 + K)

B. Group II - Ionic Salts - metal oxides compounds

6) Metal oxides are called (*basic oxides, acidic oxides, neutral oxides*)
7) Metal oxides react with water to give (*hydroxide ion, hydronium ion, oxide ion*)
8) All metal oxides of representative elements are (*white ionic salts, colored ionic salts*).
9) A metal oxide in water turns (*blue, red*) to (*blue, red*)
10) Phenolphthalein turns (*pink, blue ,red*) in the presence of hydroxide ion which is a base.
12) In general, the melting point (*increases, decreases, remains the same*) with increasing atomic number
13) In general, the boiling point (*increases, decreases, remains the same*) with increasing atomic number
14) Group II metal oxide chemical formula will <u>always</u> have one metal ion attached to two hydroxides (*true, false*)

C. Group I - Elements - Alkali Metals

15) Group I elements are stored under a layer of (*water, ethanol, mineral oil*) in the laboratory.
16) Group I elements react violently with water to produce metal (*hydroxide, hydride*) and hydrogen gas.
17) Group I elements react violently with and the reaction is (*endothermic, exothermic*).
18) Group I elements react violently with water and the water layer becomes (*colorless, pink*) if test with phenolphthalein.
19) Group I elements are also known as (*alkali, alkaline earth*) metals.
20) Of the three alkali elements tested in water, all three were (*oxidized, reduced*) to M(1+) cations.
21) List these elements Li, Na, K in order of increasing reactivity. Base on your graphical analysis of atomic radii and ionization energy data in part I, give a reasonable explanation for your ranking.

22) In terms of electronic structure why do elements in the same group display similar chemical properties

D. Reactivity trends in halogens.

This activity allowed you to determine whether electron affinity increases or decreases with the halogens by pitting molecular halogens (Cl_2, Br_2, I_2) against different halide salts (KCl, KBr, KI). The halogen with the greater electron affinity will emerge in ionic form (Cl^-, Br^-, I^-) while the lesser electron affinity will emerge as a molecular halogen element (Cl_2, Br_2, I_2). The winner will appear in ionic form and the color of the solution indicates the "loser"

<u>All of the halogens have significant electron affinity (tendency to gain or retain electrons) to become halide ion</u>. Expect chlorine has the greatest affinity of the three listed here.

one molecule $Cl_{2\ (g,zq)}$ + 2 e^- → two halide ions $Cl^-_{(aq)}$
yellow chlorine — colorless chloride ions

one molecule $Br_{2\ (l,zq)}$ + 2 e^- → two halide ions $Br^-_{(aq)}$
brown bromine — colorless bromide ions

one molecule $I_{2\ (s,zq)}$ + 2 e^- → two halide ions $I^-_{(aq)}$
purple iodine — colorless iodide ions

	reactants				products		
observed in lab	$Cl_{2\ (g,zq)}$ yellow	+	$2NaI_{(aq)}$ colorless	→	$I_{2\ (g,zq)}$ purple	+	$2NaCl_{(aq)}$ colorless

where Na^+ was a spectator ion in the reaction so it can be shown that

	$Cl_{2\ (g,zq)}$ yellow	+	2 $I^-_{(aq)}$ colorless	→	$I_{2\ (g,zq)}$ purple	+	2 $Cl^-_{(aq)}$ colorless

and the resulting color change from yellow reactant to purple product was noted

1) Would the following be observed? Explain.

	$I_{2\ (g,zq)}$ purple	+	2 $Cl^-_{(aq)}$ colorless	→	$Cl_{2\ (g,zq)}$ yellow	+	2 $I^-_{(aq)}$ colorless

2) List these elements Cl_2, Br_2, I_2 in order of increasing reactivity to be reduced. Base on your graphical analysis of atomic radii and ionization energy data in part I, give a reasonable explanation for your ranking.

3) All three halogen are diatomic molecules like to be (*reduced, oxidized*) thus they are (*oxidizing, reducing*) agents Circle the right words.