Question: How do we use the model of the electronic structure of the atom to understand periodic trends of the elements?

I. Data Collection

Using a web browser access the following address:
http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/matters/periodicTbl2.html

When the animation starts you will see Figure I below:

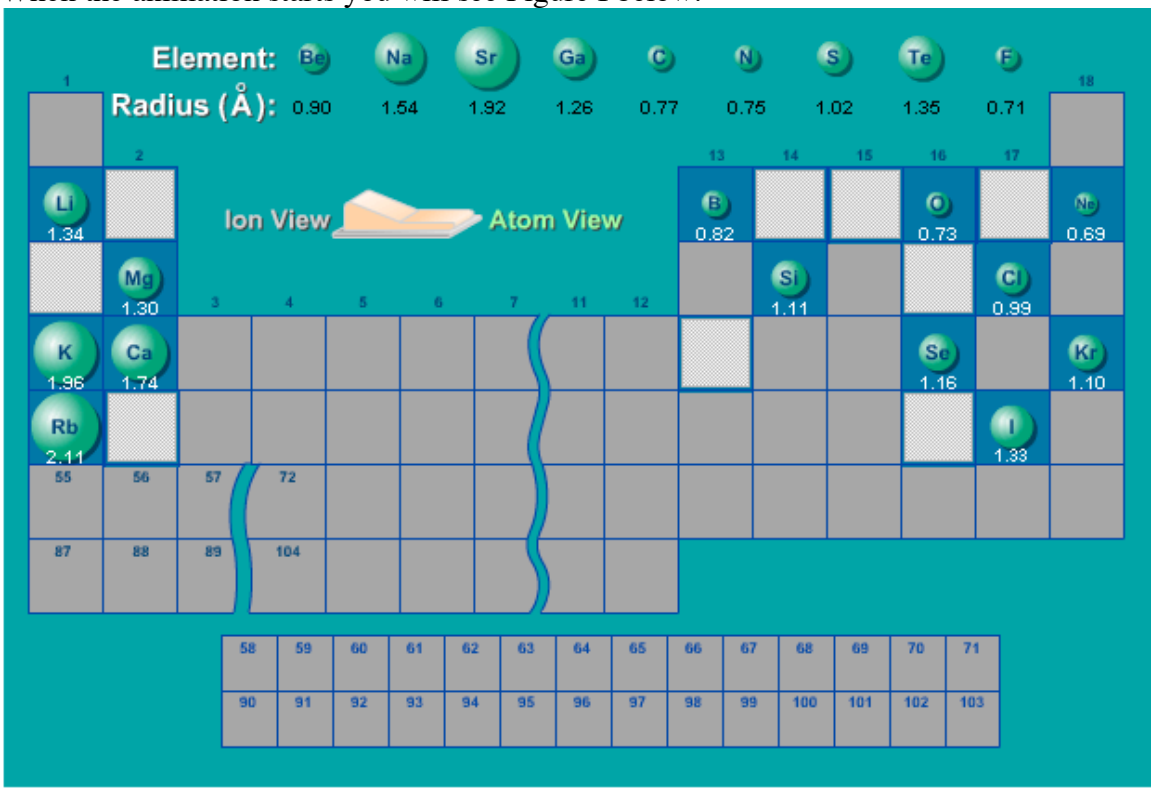

Figure I.

A. Look at the atomic sizes shown in the table and describe all the trends that you see in the space below.

Using the mouse, click on an atom in the row of atoms above the periodic table and drag them to their respective location in the periodic table.
Complete the same information by listing the atoms and their atomic radii in the Periodic Table in Figure I above.

II. Data Analysis and Interpretation

A. Select one of the Groups (1, 2, 16 or 17) in Atom View and complete the following the Table below:

(a) Element symbol	(b) Atomic Radii	(c) Nuclear Charge (# of protons)	(d) Total # of electrons	(e) Electron configuration	(f) # of inner core electrons	(g) # of valence electrons	(h) Level the valence electron(s) occupy

Table I.

After completing Table I. work with several other students or participate in a class discussion and answer parts B - E below.

B. Which columns (c – h) in Table I. cannot explain the trend in atomic radii observed in your group and why?

C. Which columns (c – h) in Table I. explain the trend in atomic radii observed in your group and why?

D. Which column (c – h) in Table I. best explains the trend in atomic radii observed in your group and why?

E. Write a general statement that explains the trend in atomic radius that applies to any Group in the Periodic Table.

III. Data Analysis and Interpretation

A. Select one of the periods in the atom view and complete the table below.

(a) Element symbol	(b) Atomic Radii	(c) Nuclear Charge (# of protons)	(d) Total # of electrons	(e) Electron configuration	(f) # of inner core electrons	(g) # of valence electrons	(h) Level the valence electron(s) occupy

Table II.

After completing Table II. work with several other students or participate in a class discussion and answer parts B - E below.

B. Which columns (c – h) in Table II. cannot explain the trend in atomic radii observed in your period and why?

C. Which columns (c – h) in Table II. explain the trend in atomic radii observed in your period and why?

D. Which column (c – h) in Table II. best explains the trend in atomic radii observed in your group and why?

E. Write a general statement that explains the trend in atomic radius that applies to any Group in the Periodic Table.

IV. Data Analysis and Interpretation

A. Effective nuclear charge (ENC) is a term used to describe the amount of nuclear charge experienced by a particular electron in an atom. Nuclear charge is the total positive charge in the nucleus. For example the nuclear charge for a carbon atom is +6. The nuclear charge is equivalent to the atomic number for an element. Carbon has six protons so consider the following information;

(a) Element symbol	(b) Nuclear Charge (# of protons)	(c) Total # of electrons	(d) Electron configuration	(e) # of inner core electrons	(f) # of valence electrons	(g) Level the valence electron(s) occupy	(h) Effective Nuclear Charge (ENC)
C	+6	6	$1s^2 2s^2 2p^2$	2	4	2	+4

If we focus on the electron configuration for carbon we see there are 4 electrons in the second level and two electrons in the first level. Electrons in the second level are further away from the nucleus. The 2 electrons in the first level (inner core electrons) partially shield the valence electrons from some of the nuclear charge. To a first approximation we will assume each inner core electron shields one proton from the electrons in the outer most level (valence electrons).

The ENC is calculated by subtracting the number of inner core electrons (IC) from the total nuclear charge (Z): ENC = Z – IC. In the case of carbon, ENC = +6 – 2 = +4.

Transfer columns (a – h) from Table I and Table II into Table III below.

(a) Group Element symbol	(b) Atomic Radii	(c) Nuclear Charge (# of protons)	(d) Total # of electrons	(e) Electron configuration	(f) # of inner core electrons	(g) # of valence electrons	(h) Level the valence electron(s) occupy	(i) Effective Nuclear Charge (ENC)
Period Element symbol								

Table III.

B. Complete column (i) in Table IV for each element.

C. In the space below show the calculation for ENC for any two of the elements in Table III.

After completing Table III. work with several other students or participate in a class discussion and answer parts D - F below.

D. Is there a relationship between ENC and the trend in atomic radius for the elements in the Group from Table I? Explain.

E. Is there a relationship between ENC and the trend in atomic radius for the elements in the period from Table II? Explain.

F. Hypothetical statement made by a student to another student:

> "When I look at Figure I. it appears to me that as the nuclear charge increases the atomic size increases."

Cite evidence that supports and/or refutes this student's statement.

V. Data Collection

Switch to the Ion View.

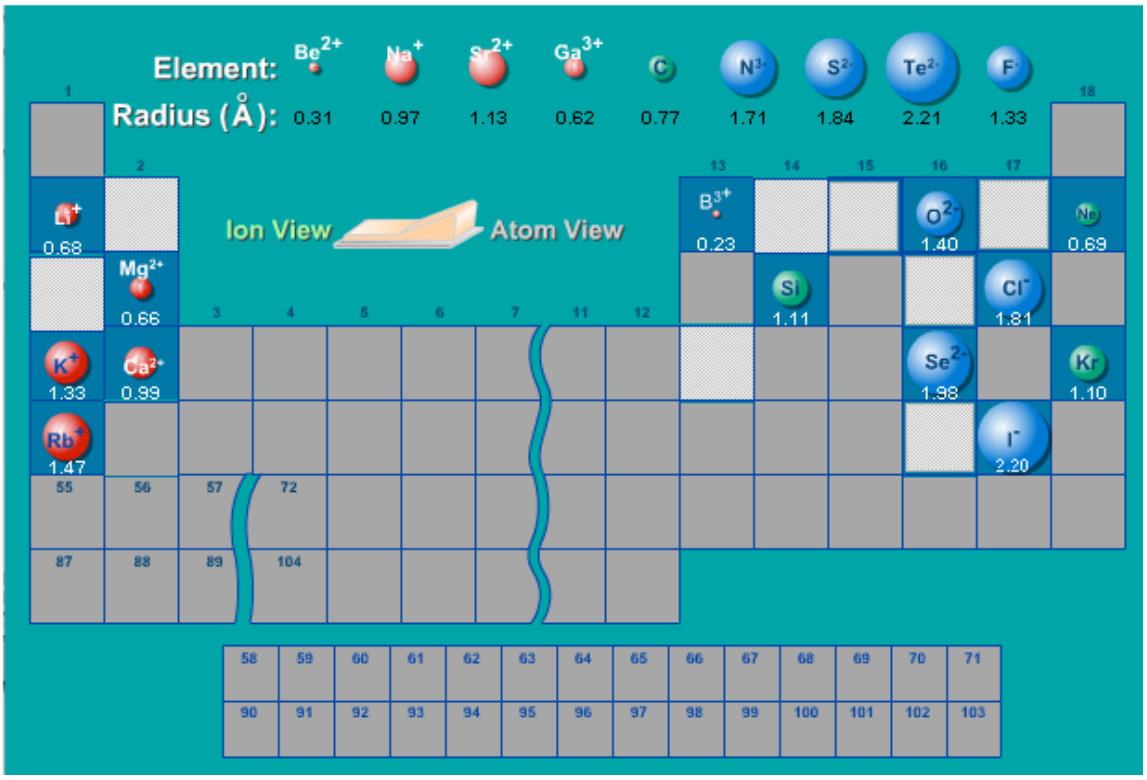

Figure II.

Using the mouse, click on an ion in the row of ions above the periodic table and drag them to their respective location in the periodic table.
Complete the same information by listing the ions and their ionic radii in the Periodic Table in Figure II above.

VI. Data Analysis and Interpretation

A. Using the atomic and ion size information from Figure I and Figure II. select one metal from Group 1 or 2 and select one nonmetal from Group 16 or 17 and complete Table IV. In Table IV. enter the metal you selected in the first row and complete the row of information. In the next row below enter the cation for that metal and complete the information in the row. Do the same for the nonmetal you selected.

(a) Element symbol	(b) Atomic /ion Radii	(c) Nuclear Charge (# of protons)	(d) Total # of electrons	(e) Electron configuration	(f) # of inner core electrons	(g) # of valence electrons	(h) Level the valence electron(s) occupy
metal							
metal ion							
nonmetal							
nonmetal ion							

Table IV.

After completing Table IV. work with several other students or participate in a class discussion and answer parts B - F below.

B. Which columns (c – h) in Table III. cannot explain the trend in radii observed for the metal atom and its cation and why?

C Which columns (c – h) in Table III. explain the trend in radii observed for the metal atom and its cation and why?

D. In general what is the relationship between the radius for the neutral metal atom and its cation?

E. Which column (c – h) in Table III. best explain the trend in radii observed for the metal atom and its cation and why?

F. Write a general statement that explains the trend in radius between a metal atom and its ion that applies to any combination of metal and its cation.

G. Which columns (c – h) in Table III. cannot explain the trend in radii observed for the nonmetal atom and its anion and why?

H. Which columns (c – h) in Table III. explain the trend in radii observed for the nonmetal atom and its anion and why?

I. In general what is the relationship between the radius for the neutral nonmetal atom and its anion?

j. Which column (c – h) in Table III. best explains the trend in radii observed for the nonmetal atom and its anion and why?

K. Write a general statement that explains the trend in radius between a nonmetal atom and its anion that applies to any combination of nonmetal atom and its anion.

Complete the Table below.

Element symbol	Ion Radii	(c) Nuclear Charge (# of protons)	(d) Total # of electrons	(e) Electron configuration	(f) # of inner core electrons	(g) # of valence electrons	(h) Level the valence electron(s) occupy	(i) Effective Nuclear Charge (ENC)
S^{2-}								
Cl^{-}								
K^{+}								
Ca^{2+}								

Table V.

Which columns (c – h) in Table V. cannot explains the trend in ion radii observed in this selection of ions and why?

Which columns (c – h) in Table V. explain the trend in ion radii observed in this selection of ions and why?

Which column(s) (c – h) in Table V. best explains the trend in ion radii observed in this selection of ions and why?

Write a general statement that explains the trend in ion radius that applies to a related (isoelectronic) set of ions in the Periodic Table.