

## Chemistry Lecture #32: Atomic & Ionic Radius

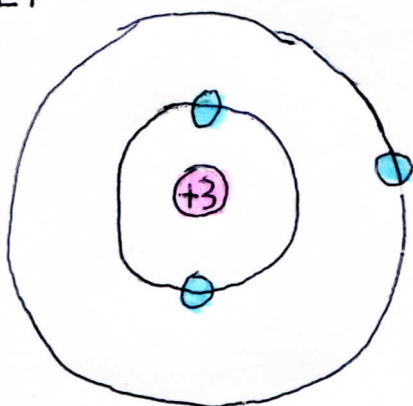
### Atomic Radius

Atomic radius is the distance of the outer electrons from the nucleus.

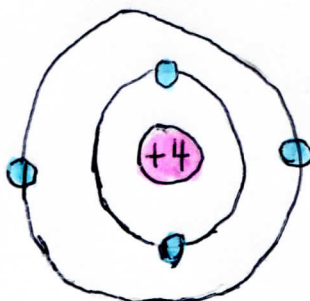
Electrons, which have a negative charge, are attracted to the positively charged nucleus.

If the positive charge in the nucleus increases, the electrons will be pulled closer, and the radius will decrease.

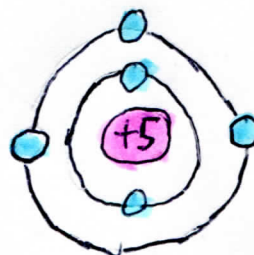
Li



Be



B



On the periodic chart, radius decreases from left to right because positive charge in the nucleus increases.

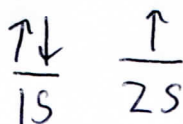
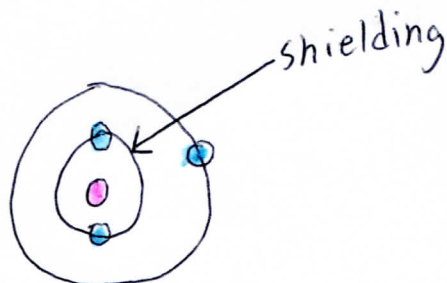
What happens to the radius when we go down a column? The next set of pictures shows the radius of the atoms in group 1A

of the periodic chart. We'll start at the top with hydrogen, then go down with lithium and then sodium.

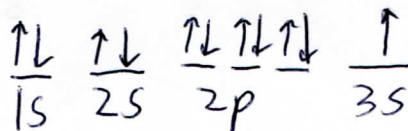
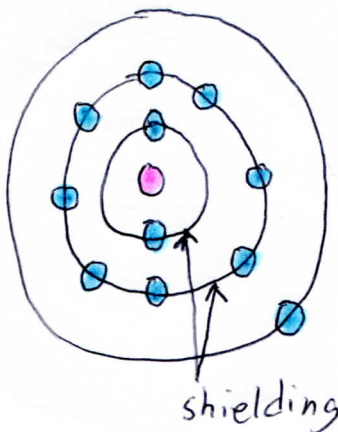
H



Li



Na



As we go down a column, the number of inner energy shells between the outer electrons and the nucleus increases.

These shells shield the outer electrons from the nucleus. Consequently, they are held less tightly, resulting in a larger radius.

Thus, radii increase going down a column due to shielding.

The overall trend of radius size across the periodic chart is:

- Left to right, radius decreases
- Top to bottom, radius increases

If you go diagonally from the bottom left of the chart to the upper right, you'll go from the largest radius to the smallest radius.

atomic size decreases →							
1	2	3	4	5	6	7	8
H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Cs	Ba	Tl	Pb	Bi	Po	At	Rn
↘ atomic size decreases ↗							

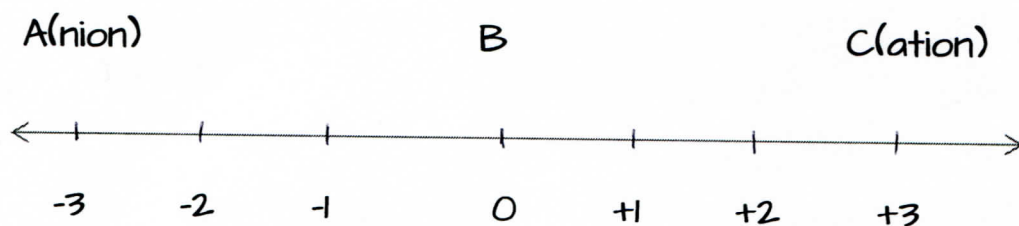


## Radii of Ions

An ion is an atom or group of bonded atoms that has lost or stolen electrons. Ions have a positive charge when they lose electrons. The more electrons they lose the more positive charge they have. Ions with a positive charge are called cations.

If an atom steals electrons, it will have a negative charge. The more electrons it steals the more negative charge it will have. Ions with a negative charge are called anions.

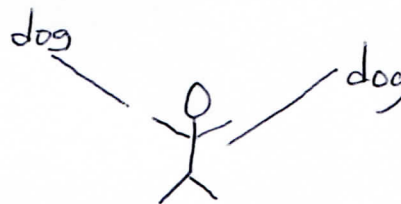
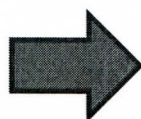
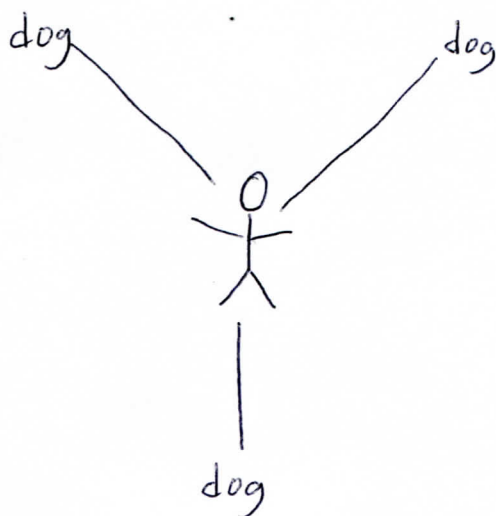
One way to remember that anions are negative and that cations are positive is to associate them with a number line and the alphabet. The letters of the alphabet are listed from left to right, and start with A, B, C, and so on. A number line starts with negative numbers on the left and moves to positive numbers on the right.



Notice that "anion" is above the negative region and "cation" is above the positive region.

The radii of ions are different from the radii of neutral atoms. Anions have a larger radii, and cations have a smaller radii. To explain why, we'll use an analogy: a man trying to hold three dogs on lease.

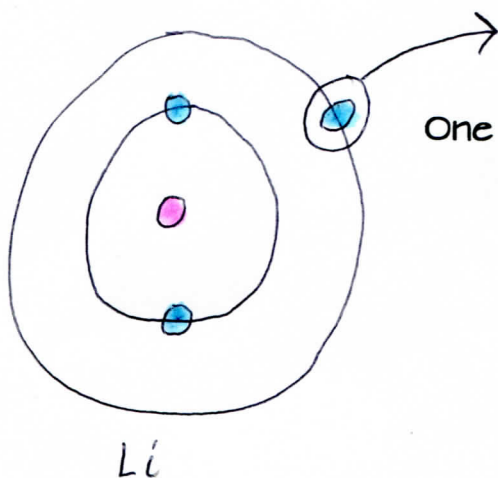
Our hapless man represents the positive nucleus trying to pull electrons towards itself. The three dogs, each on its own leash, represent the electrons. In this case, each dog is trying to run away, and the man is pulling on the leashes in an attempt to pull the dogs/electrons in.



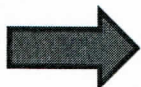
Fewer dogs to hold, so they are pulled closer.

Now suppose one dog gets away. With one less dog, you can pull the remaining dogs closer.

Now suppose a lithium atom loses an electron. What happens to the atomic radius?



One electron removed



Remaining electrons held more tightly, making a smaller radius.

When atoms lose electrons (or gain positive charge), radius decreases.

Conversely, when atoms gain electrons (or negative charge), the radius increases.

Which has the larger radius?

- a. Na or  $\text{Na}^+$    b. Cl or  $\text{Cl}^-$    c.  $\text{H}^+$  or  $\text{H}^-$    d.  $\text{Fe}^{2+}$  or  $\text{Fe}^+$   
e.  $\text{S}^{2-}$  or  $\text{S}^-$    f. Mg or Sr   g. Fr or F   h. Si or S

Answers

- a. Na   b.  $\text{Cl}^-$    c.  $\text{H}^-$    d.  $\text{Fe}^+$   
e.  $\text{S}^{2-}$    f. Sr   g. Fr   h. Si