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VALENCE ELECTRONS AND IONS

Part III: Reactivity: How do valence electrons determine an element's chemical properties?

As it turns out, the key number for the valence shell is the number "8". The number "2" is also a key number but only for the atoms hydrogen, helium, lithium, beryllium, and boron. So, what makes 8, and sometimes 2, key numbers? Scientists learned a simple rule of thumb about atoms. They tend to combine so that their valence shells are full of electrons. This is called the octet rule. (Note the root oct = 8 in the word octet, like octopus!).

This means two things:

(1) If a neutral atom's valence shell is full, then the atom will not react with other atoms.

(2) If a neutral atom's valence shell has space available, then the atom will react with other atoms based on the number of electrons found in the valence shell and other chemical properties you will learn about in later investigations.

We begin with the following three generalizations:

a. Some atoms only need 1, 2, or 3 more electrons to fill the valence shell. These electrons come from other atoms when they react.

b. Some atoms need to remove 1, 2, or 3 electrons to have the energy layer below become the valence shell that is already full. The removed electrons are accepted by other atoms when they react.

c. Some atoms tend to react with other atoms in a way electrons are shared rather than giving up or receiving electrons.

Refer to your diagrams from Part 1 to determine the number of valence electrons for each atom listed then complete the chart below. Hydrogen is a special case and has been completed at the bottom of the chart for you. Answer the questions on the next page based on the completed chart.

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Part III: Reactivity: How do valence electrons determine an element's chemical properties?

Refer to your diagrams from Part I to determine the number of valence electrons for each atom listed, and then complete the chart below.

Neutral atom	Number of valence electrons	Remove 1, 2, or 3 electrons to have the layer below become the valence shell that is already full	Just needs 1, 2, or 3 electrons to fill the valence shell	Shares electrons rather than giving up or receiving electrons
Lithium				
Beryllium				
Boron				
Nitrogen				
Oxygen				
Fluorine				
Sodium				
Magnesium				
Aluminum				
Phosphorus				
Sulfur				
Chlorine				
Potassium				
Calcium				
Carbon				
Silicon				
Hydrogen				

Refer to chart on the previous page and your diagrams to answer these questions.

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1. Look at the diagrams of helium, neon, or argon to explain why these atoms did not appear on the chart.

_____

2. Will helium, neon, or argon atoms react with other atoms? ____ Why or why not?

_____

3. Use the chart to explain why the atoms of carbon and silicon differ from the other atoms listed.

_____

_____

4. If two electrons are removed from beryllium during a reaction, which energy level becomes the valence shell? _____

5. If one electron is removed from potassium during a reaction, which energy level becomes the valence shell? _____

6. Does it make sense that a chlorine atom would accept two electrons?_____ Why or why not?

_____

_____

7. Notice a neutral hydrogen atom is a special case as it can accept, remove, OR share electrons during reactions with other atoms. If a single electron is removed from hydrogen, the remaining positive proton number in the atom is _____ and remaining negative electron number is _____. Do you think this atom is still neutral? _____ Why or why not? _____

8. Chemical properties of matter describe a "potential" to undergo some change or reaction. How do valence electrons determine the chemical property of reactivity for the following atoms: hydrogen, neon, carbon, fluorine, and sodium? Use the words reactive (or reactivity), valence shell, remove electrons, accept electrons, and share electrons in your sentences as appropriate.

Hydrogen: _____

Neon: _____

Carbon: _____

Fluorine: _____

Sodium: _____

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Part IV: When Atoms Aren't Neutral…

So far, you have only worked with neutral atoms, meaning the number of positive protons is exactly the same as the number negative electrons. Now it is clear that atoms tend to combine in ways that fill valence shells with electrons. When electrons are removed or accepted by other atoms, the proton number is no longer the same as the electron number so the atom is charged. Remember that protons and electrons are equal in number for neutral atoms.

Charged atoms are not neutral. They are either positive, with more protons than electrons as a result of removed electrons. Or, they are negative, with more electrons than protons as a result of accepting electrons from other atoms. Charged atoms are called ions. Ions are either positive ions (more protons than electrons), or negative ions (more electrons than protons).

First, you will build neutral atoms, complete a diagram, and then remove or accept electrons to fill valence shells, and finally determine the charge of the resulting ions by counting the number of positive protons and negative neutrons. Use two Atomic Structure Handouts to go through the following example.

- Partner A builds a neutral atom of sodium, atomic number 11 with a total mass of 23 amu. Use the model to transfer the information so that both partners complete their diagram labeled: REACTION 1: SODIUM ATOM. Write the number of (p+) and (n0) in the nucleus and fill the appropriate circle with a red pencil. Leave this model the way it is and start another atom on the second handout.
- On the second handout, Partner B builds a neutral atom of chlorine, atomic number 17 with a total mass of 35. Both partners use the model to transfer the information to the diagram labeled: REACTION 1: CHLORINE ATOM. Writing in the number of (p+) and (n0) in the nucleus and filling the appropriate circle with a red pencil.
- Count the number of positive protons and negative electrons for each of these atoms and record the numbers in the space provided below each diagram. (This example has been completed for you.)
- Remember what you learned about removing and accepting electrons in Part 3. Sodium has one valence electron, and when it is removed, the energy level below reaches a full valence number according to the octet rule. Chlorine can accept an electron to fill the last empty space in the valence

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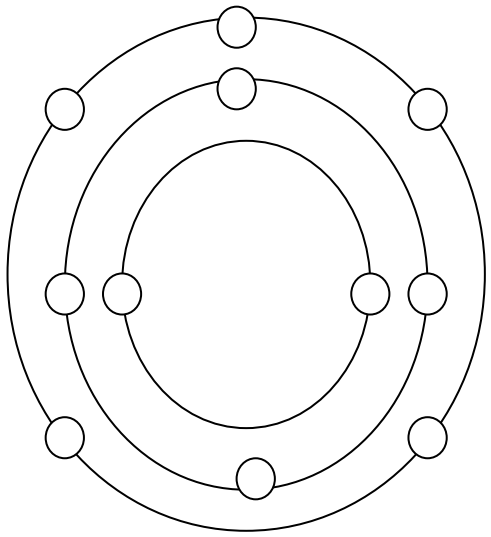
shell. Complete this reaction between the atom models by moving one of the protons to change them from atoms to ions.

- Draw new diagrams of these two ions the space labeled REACTION 1 SODIUM ION and CHLORINE ION. Count the number of positive protons and negative electrons for each of these ions. Record them in the space provided below each diagram.
- The charge on the sodium ion is positive one and is written Na^{1+}. The charge on the chlorine ion is negative one and is written Cl^{1-}. Ions are written as the symbol of the element and a positive or negative number as a subscript. For example, if an atom called X accepted 3 electrons to fill a valence, it would be written X^{3-} because it now has three extra negative charges from the electrons. Use the space provided to determine the charges on the ions of sodium and chlorine and record information as directed.
- Complete REACTION 2 and REACTION 3 as you did for the first example reaction of sodium and chlorine. Build neutral atoms first, analyze the electron movement and then change them to ions by moving the lentil electrons. Complete the diagrams for each reaction.

By the way, the sodium and chlorine ions that you just built form salt when they react. The kind of salt you put on your food is called sodium chloride! Think of that the next time you salt your food!

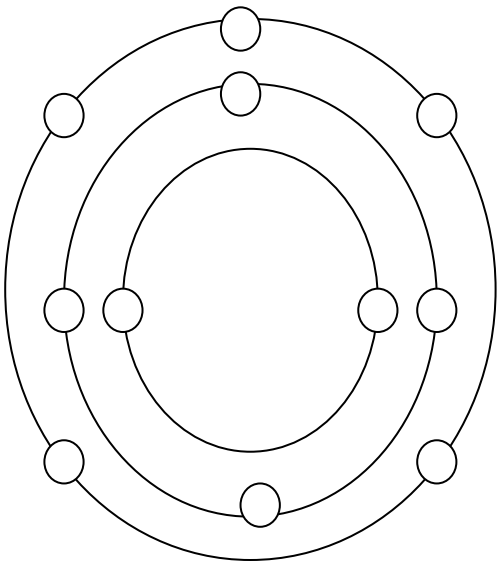
REACTION 1

Sodium Atom



Atomic Number	11
Atomic Mass	23
Number of + charges	11
Number of – charges	11
Is valence shell full?	No

Chlorine Atom



Atomic Number	17
Atomic Mass	35
Number of + charges	17
Number of – charges	17
Is valence shell full?	No

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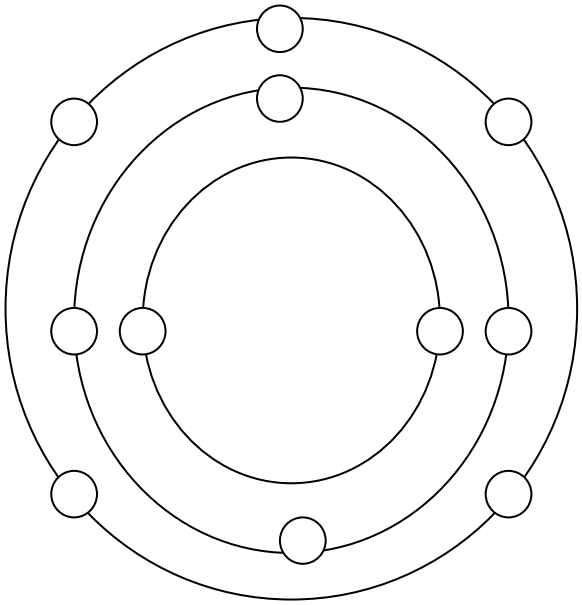
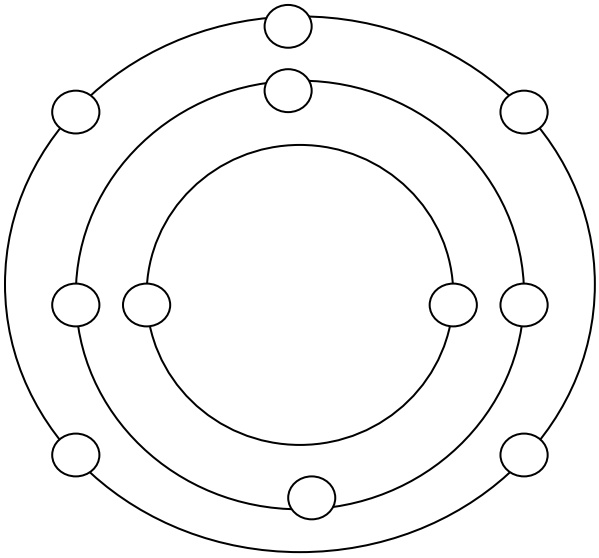
Sodium Ion



Atomic Number 11
Atomic Mass 23
Number of + charges 11
Number of – charges 10
Is valence shell full? Yes
What is the # of excess + or – charges in this ion? 1 +

Show how this ion is written: Na^{1}

Chlorine Ion



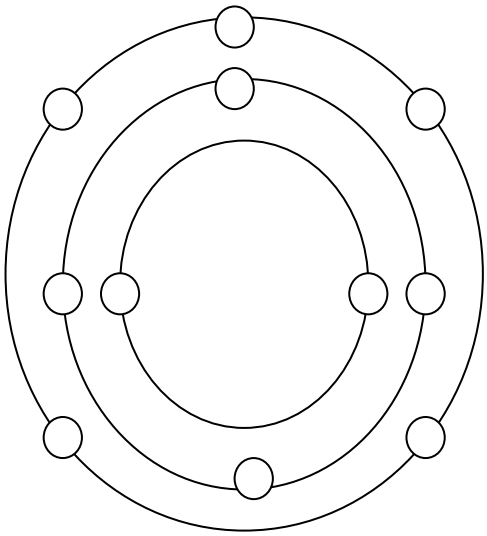
Atomic Number 17
Atomic Mass 18
Number of + charges 17
Number of – charges 18
Is valence shell full? Yes
What is the # of excess + or – charges in this ion? 1—

Show how this ion is written Cl^{1-}

REACTION 2

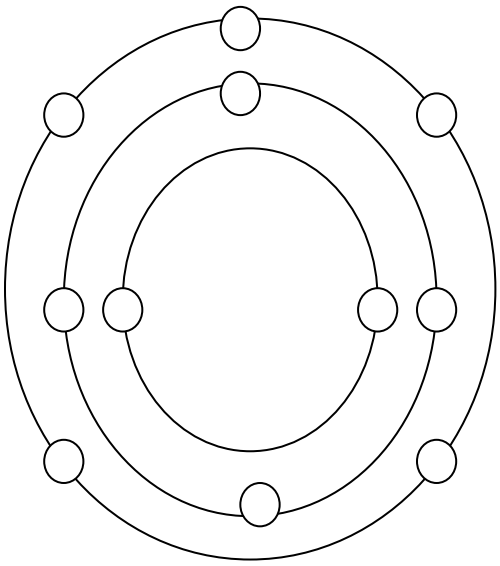
Lithium Atom

Atomic Number 3
Atomic Mass 7
Number of + charges ____
Number of – charges ____
Is valence shell full? ____



Fluorine Atom

Atomic Number 9
Atomic Mass 19
Number of + charges ____
Number of – charges ____
Is valence shell full? ____



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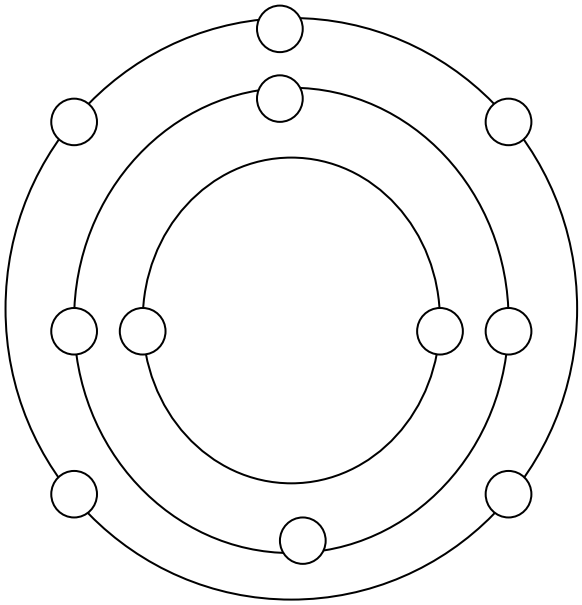
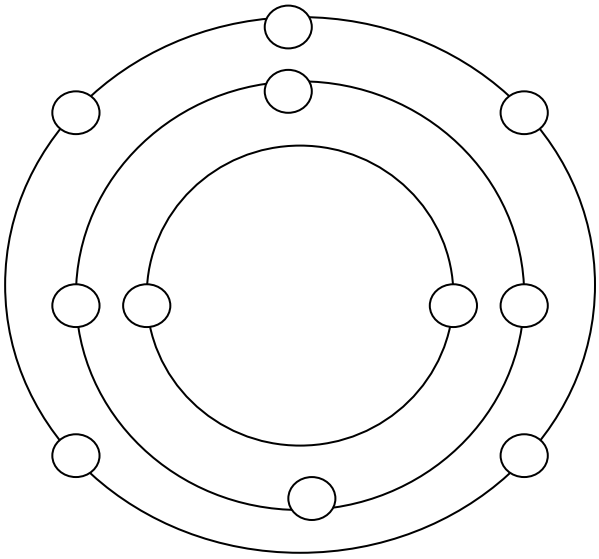
Lithium Ion



Atomic Number 3
Atomic Mass 7
Number of + charges _____
Number of – charges _____
Is valence shell full? _____
What is the # of excess + or – charges in this ion? _____

Show how this ion is written: _____

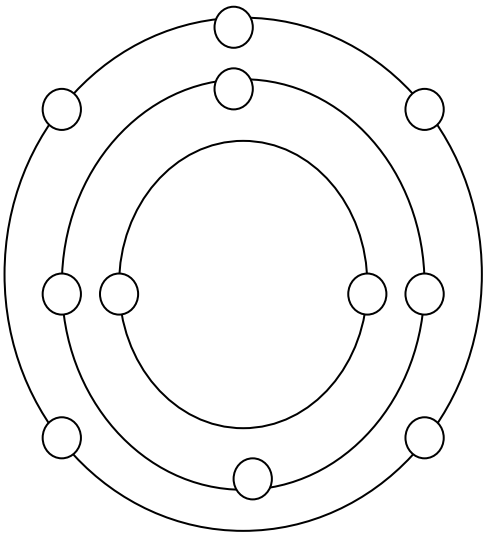
Flourine Ion



Atomic Number 9
Atomic Mass 19
Number of + charges _____
Number of – charges _____
Is valence shell full? _____
What is the # of excess + or – charges in this ion? _____
Show how this ion is written _____

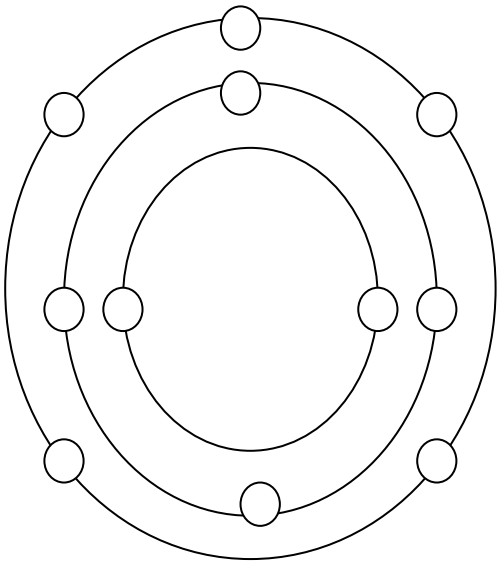
REACTION 3

Calcium Atom



Atomic Number 20
Atomic Mass 40
Number of + charges _____
Number of – charges ____
Is valence shell full? _____

Oxygen Atom



Atomic Number 8
Atomic Mass 16
Number of + charges ____
Number of – charges ____
Is valence shell full? _____

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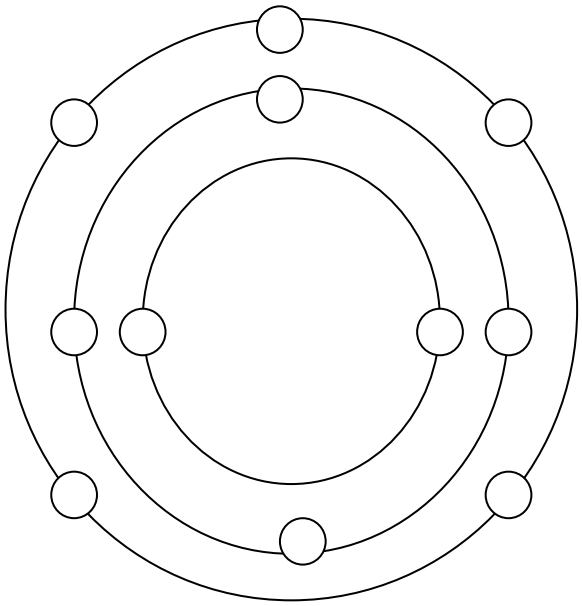
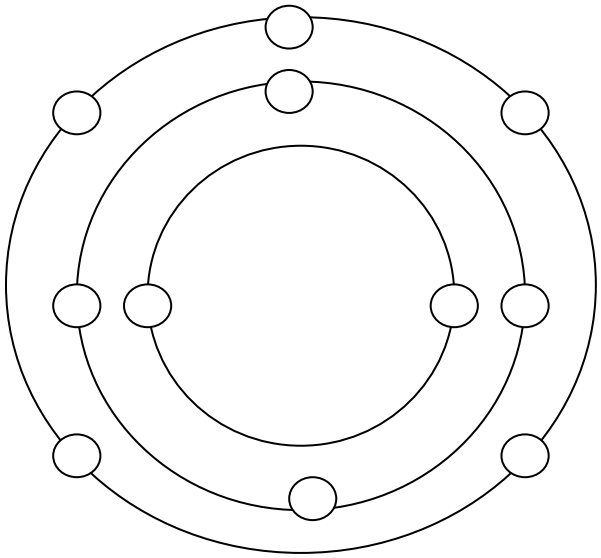
Calcium Ion



Atomic Number 20
Atomic Mass 40
Number of + charges ____
Number of – charges ____
Is valence shell full? _____
What is the # of excess + or – charges in this ion? _____

Show how this ion is written: _____

Oxygen Ion



Atomic Number 8
Atomic Mass 16
Number of + charges _____
Number of – charges _____
Is valence shell full? _____
What is the # of excess + or – charges in this ion? _____
Show how this ion is written _____

Part V: Identifying Elements

So, what makes fluorine "fluorine"? Or sodium "sodium"? We know they are both made of protons, neutrons, and electrons. We just learned that atoms can give up, accept or share valence electrons with other atoms when they react, so we can't count on the number of electrons staying the same for any particular atom. What about protons or neutrons? Protons and neutrons don't seem to be given up, accepted or shared with other atoms. And remember, the number of protons is the same as the atomic number, which is pretty convenient because the atomic number is printed by each element on the periodic table. Look at the next chart and try to identify some mystery atoms. After completing your predictions using the clue provided, your teacher will identify each of the mystery atoms.

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Mission: Identify the name of the element based on the clue provided for each. You may use this lab and a periodic table to help solve the mysteries.

CLUE: This element is made from atoms with…	Predicted identity
2 ELECTRONS	
47 PROTONS	
99 PROTONS	
92 PROTONS	
31 NEUTRONS	
18 PROTONS	

REFLECTION AND CONCLUSION QUESTIONS:

1. The number of _____ can be used to identify an element.
2. Which elements did you determine would not react with others?
3. What information must you have to determine the number of neutrons in an element?
4. Which energy levels of the electron cloud fill first?
5. How are the number of *electrons determined* in a neutral atom?
6. What causes some atoms to be chemically reactive?
7. What is the simple rule of thumb that scientist call the octet rule?
8. Use your diagrams for neutral atoms to determine how the ions would form and be written for:

a magnesium (Mg) ion a sulfur (S) ion a nitrogen (N) ion