Name: _____ Date: _____

Gizmo Activity: Atomic Structure

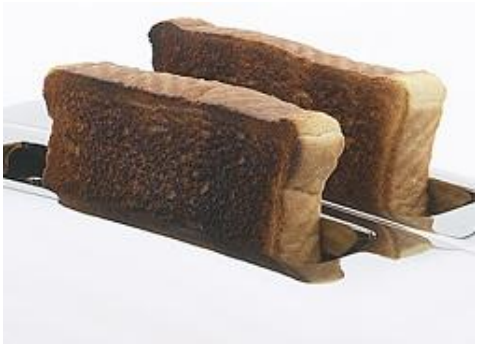
[Note: This activity requires you to use the Element Builder *Gizmo.]*

Learning goals
After completing this activity, you will be able to …

- Describe the structure of the atom.
- Describe the role of protons in determining an atom's identity.
- Explain what a valence electron is and how valence electrons play a role in forming chemical bonds.
- Interpret the periodic table.
- Identify elements that are important in the composition of Earth's oceans, atmosphere, and crust.

Vocabulary: atom, atomic number, charge, electron, electron cloud, electron dot diagram, energy level, group, ion, mass number, neutron, noble gases, nucleus, period, periodic table, proton, subatomic particle, universal mass unit, valence electrons

Warm-up questions:



1. Have you ever burned toast? The black stuff that covers the bread is the element carbon. What do you notice when you scrape at the carbon on burned toast with a knife?

   _____

   _____

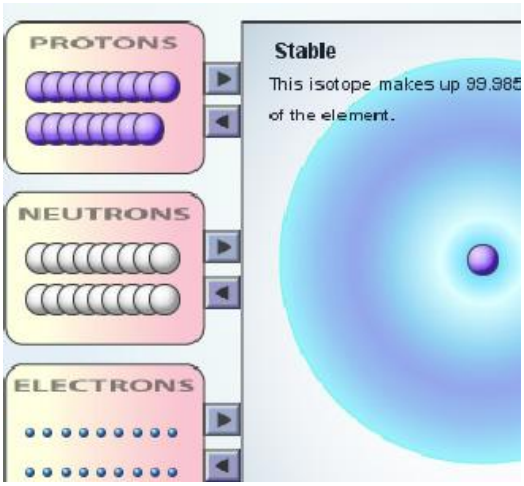
2. Suppose you could take each grain of carbon dust and divide it into a thousand pieces, and then divide each of those pieces into a thousand pieces. If you did this long enough, what would you end up with?

   _____

   _____

Activity A: Atoms

If you divide an element into its smallest components, you end up with extremely tiny particles called **atoms**. An atom is the smallest particle of an element that still has the properties of the element. A carbon atom measures about 140 picometers across. (A picometer is one trillionth of a meter.) That means you would have to line up 7,142,857,143 carbon atoms to equal one meter.



Atoms are made of smaller particles called **subatomic particles**. There are three types of subatomic particles inside the atom: **protons**, **neutrons**, and **electrons**. You will explore how these particles fit inside atoms using the *Element Builder* Gizmo.

Open the Gizmo. Notice the three kinds of subatomic particles on the left side of the Gizmo. You can add particles to the atom using the right arrow button (▶). To begin, add a few of each particle to the atom.

1. What three particles make up an atom? _____

2. The **nucleus** is the dense center of the atom. What two particles are found in the nucleus?

   _____

3. Click **Play** (▶). What do you notice about the electrons? _____

   _____

   The region where electrons go around the nucleus is called the **electron cloud**.

4. Click **Reset** (↺). There should be only one proton in the atom now. Turn on **Show element name**.

   A. What is the name of the element now? _____

   B. Click the arrow to add one more proton.

      What is the name of the element now? _____

   C. Add one more proton. What is the name of the element now? _____

   D. Use the arrow keys to add several neutrons and electrons.

      Do neutrons and electrons change the identity of the element? _____

Activity B: Charge and mass

Have you ever rubbed a balloon on your head and then felt it stick to your hair? If you have, you have experienced the effects of electrical **charge**. Protons have a positive charge of 1+, and electrons have a negative charge of 1–. Neutrons have no charge. If an atom has an equal number of protons and electrons, it will be neutral. If the numbers are unequal, the atom will have a charge. Charged atoms are called **ions**.

When you rub a balloon on your head, electrons are rubbed off of your hair onto the balloon. This gives the balloon a negative charge and your hair a positive charge. The opposite charges create an attractive force between your hair and the balloon. The same attractive force keeps the electrons in orbit around the nucleus of the atom.

The mass of protons and electrons is measured in **universal mass units**, or u. One universal mass unit is about the mass of a proton, but not exactly: A single proton has a mass of 1.007 u. A neutron has a mass of 1.009 u. Electrons are much less massive than protons and neutrons. An electron's mass is only 0.0005486 u.

There is an interesting reason that the mass of a single proton is greater than 1 u. You may have heard of Einstein's famous equation, $E = mc^2$. In this equation, E stands for energy, m for mass, and c for the speed of light. Based on this equation, if you increase the energy of something (E), you also increase its mass (m). Single protons have a bit more energy than protons inside atomic nuclei, so they have more mass as well. The universal mass unit is equal to the average mass of the protons and neutrons in a carbon-12 atom.

1. How is a balloon sticking to your hair related to the structure of an atom? _____

_____

_____

_____

_____

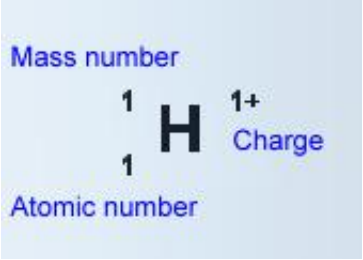
2. Fill in the chart below to summarize what you have learned so far about subatomic particles.

Particle	Location in atom	Mass (u)	Charge
Proton			
Neutron			
Electron			

3. Suppose an ion has 23 protons and 25 electrons. What would the charge of the ion be? ___

Activity C: Element notation

On the *Element Builder* Gizmo, click **Reset**. On the right side of the Gizmo, turn on **Show element name** (if necessary) and **Show element symbol**. Next, turn on **Element notation**. You should see a hydrogen symbol like the one shown at right.



There are three numbers around the element symbol. The number at upper left is the **mass number**. The number at lower left is the **atomic number**. The number at upper right is the charge.

1. Why does the current hydrogen ion have a charge of 1+? _____

   _____

2. Add one neutron to the atom.

   A. How does this affect the mass number? _____

   B. How does this affect the atomic number? _____

   C. How does this affect the charge? _____

   D. What is the name of this element? _____

3. Add one electron to the atom.

   A. How does this affect the mass number? _____

   B. How does this affect the atomic number? _____

   C. How does this affect the charge? _____

   D. What is the name of this element? _____

4. Add one proton to the atom.

   A. How does this affect the mass number? _____

   B. How does this affect the atomic number? _____

   C. How does this affect the charge? _____

   D. What is the name of this element? _____

Continue to add protons, neutrons, and electrons to the atom. Observe how each particle affects the mass number, atomic number, charge, and element name. When you are confident you know the pattern, go to the next page.

5. Make a rule: If you know the number of protons, neutrons, and electrons in an atom, describe how you would find each of the following:

   Mass number: _____

   Atomic number: _____

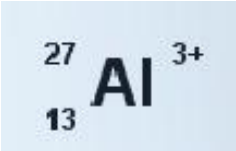
   Charge: _____

6. How many protons, neutrons, and electrons are in the aluminum (Al) atom shown below?

   Protons: _____

   Neutrons: _____

   Electrons: _____



7. A chlorine (Cl) atom has 17 protons, 18 neutrons, and 18 electrons. Write its element notation below:

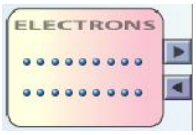
   Cl

8. An iron (Fe) atom has 26 protons, 30 neutrons, and 24 electrons. Write its element notation below:

   Fe

Activity D: Electrons

On the *Element Builder* Gizmo, click **Reset**. Add electrons to the atom one at a time until you have added 10 electrons. Observe closely how the electrons are added to the atom. Click **Play**.



1. What do you notice about how the electrons are positioned in the atom? _____

   _____

2. Notice that the electrons orbit in two concentric rings.

   A. How many electrons are in the inner ring? _____

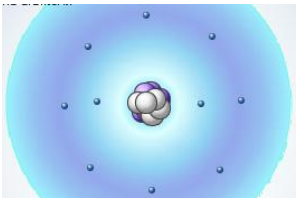
   B. How many electrons are in the outer ring? _____

   C. Add the remaining eight electrons. What do you notice? _____

      _____

The regions in which electrons orbit are called **energy levels**. The first energy level can hold up to two electrons. The second can hold eight, and the third can hold 18. (Only part of the third level is shown in this Gizmo.)

Activity E: Valence electrons



The outermost electrons in an atom are called **valence electrons**. Valence electrons are very important because they determine how reactive an element is. Because valence electrons are farthest from the attractive positive charge of the nucleus, they are the electrons that are lost most easily when ions are formed.

Atoms tend to be most stable when they have a full complement of valence electrons. Atoms can achieve a stable electron configuration by losing or gaining electrons. Atoms with three or fewer valence electrons tend to lose electrons and form positive ions. Atoms with four or more valence electrons tend to gain electrons and form negative ions. Atoms can also achieve stable electron configurations by sharing valence electrons with other atoms.

When atoms form ions or share electrons, they form bonds. For example, positive ions bond with negative ions because positive and negative charges attract. Atoms also form bonds when they share electrons. The number of valence electrons determines how likely an element is to form bonds and take part in chemical reactions. Atoms that gain, lose, or share electrons easily are very reactive. Elements that do not easily gain, lose, or share electrons are less reactive. Elements with full sets of valence electrons do not form bonds or take part in chemical reactions at all. These elements are called **noble gases**.

On the Gizmo, click **Reset**. Add a single electron to form a hydrogen atom. If necessary, turn on **Show element name**, **Show element symbol**, and **Element notation**.

1. Hydrogen can achieve a stable electron configuration by either losing its electron or gaining an electron so that the first energy level is full.

    A. Try adding an electron. What is the charge of this ion? _____

    B. Try subtracting both electrons. What is the charge of this ion? _____

2. Add one proton, two neutrons, and two electrons to make a neutral atom of helium.

    How many valence electrons does helium have? _____

    Because the first energy level is full, helium is stable without gaining or losing electrons. Because it does not gain, lose, or share electrons easily, helium does not form bonds or take part in chemical reactions. It is an example of a noble gas.

3. Add one proton, two neutrons, and one electron to make a neutral atom of lithium. Recall that the second energy level can hold eight electrons.

    A. How many valence electrons does lithium have? _____

    (Remember to only count electrons in the outermost level that has electrons.)

    B. Lithium can achieve a stable electron configuration by losing one electron or gaining seven electrons. Which do you think is more likely? _____

4. Lithium easily loses its lone valence electron to form an ion.

   What is the charge of this ion? _____ (Check your answer with the Gizmo.)

5. Add one proton, one neutron, and two electrons to make a neutral atom of beryllium. (There should be four total electrons.)

   A. How many valence electrons does beryllium have? _____

   B. How could beryllium achieve a stable electron configuration? _____

   _____

   C. What is the charge of a beryllium ion? _____

   Beryllium holds on to its electrons more strongly than lithium does, but it still loses them when it forms chemical bonds. Beryllium is slightly less reactive than lithium but is still very reactive. The symbol for a beryllium ion is Be^{2+}.

6. Create an oxygen atom with eight protons, eight neutrons, and eight electrons.

   A. How many valence electrons does oxygen have? _____

   B. How can oxygen achieve a stable electron configuration? _____

   _____

   C. What ion will oxygen form? _____

7. Create a neon atom with 10 protons, 10 neutrons, and 10 electrons.

   A. How many valence electrons does neon have? _____

   B. Does neon have to gain or lose electrons to have a full set of valence electrons?

   Explain. _____

   C. Do you think neon is very reactive or very unreactive? Explain. _____

   _____

8. Summarize: How do valence electrons relate to the ability of an atom to form bonds and

   take part in chemical reactions? _____

   _____

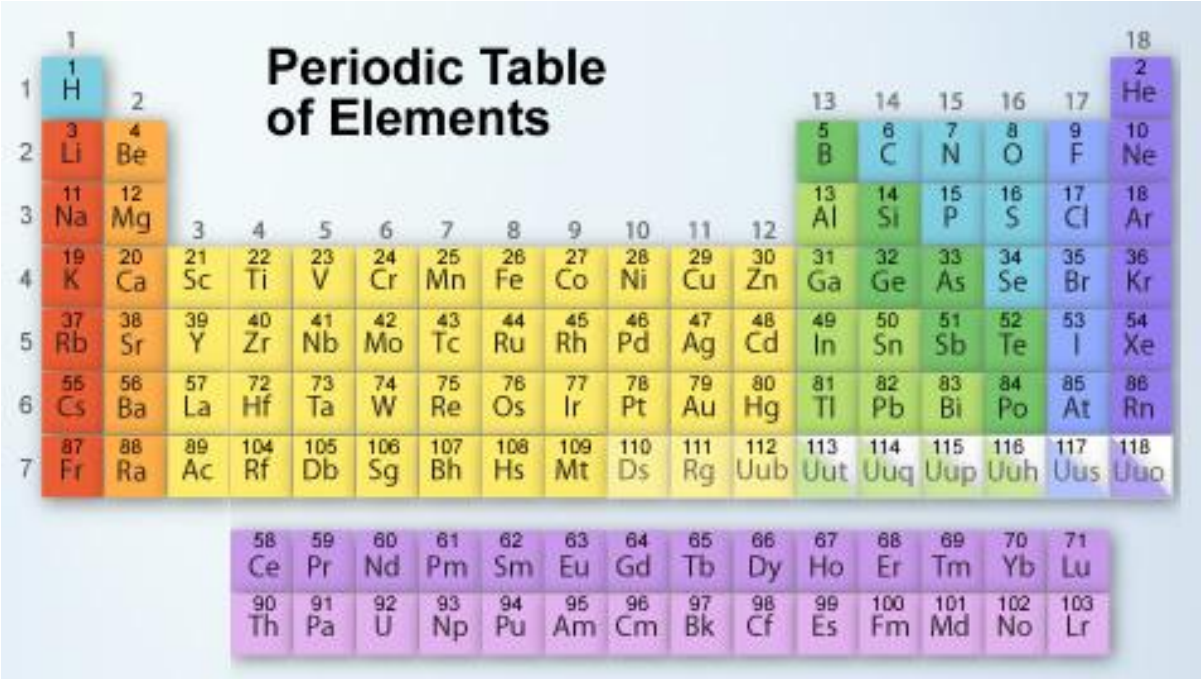
   _____

Activity F: The Periodic Table

Dmitri Mendeleev

Long before scientists knew about subatomic particles or electron configurations, they noticed that certain elements have certain properties. A Russian chemist named Dmitri Mendeleev (1834–1907) organized elements into a chart so that elements with similar properties were in the same column. The result was the first version of the **periodic table**. Mendeleev's table had gaps where he predicted new elements would be discovered. The subsequent discovery of these elements confirmed the patterns that Mendeleev had observed.

The modern periodic table is shown below. The atomic number of each element is given above the element's symbol. Each row in the table is called a **period**. Each column is called a **group**. Notice that in each period, the atomic number increases from left to right.



As you work with the periodic table, it is helpful to represent elements using **electron dot diagrams**. These are diagrams in which dots represent the valence electrons. To see examples, turn on **Show electron dot diagram** in the *Element Builder* Gizmo.

1. Use the Gizmo to create neutral atoms of each of the elements below. Draw the electron dot diagram for each neutral atom. (Remember, a neutral atom has the same number of protons and electrons.)

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

2. What do you notice about the electron dot diagrams for hydrogen (H), lithium (Li), and sodium (Na)? _____

   What does this tell you about the number of valence electrons for each of these elements?

   _____

3. What do you notice about the electron dot diagrams in each column? _____

   _____

4. Based on what you have learned so far, predict the electron dot diagrams for each of the following elements. (Use the periodic table on the previous page.)

K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe

5. Lithium (Li), sodium (Na), potassium (K), and rubidium (Rb) are all soft, silvery metals that react strongly with water. Along with cesium (Cs) and francium (Fr), they form the alkali metals family. Why do you think these elements have similar chemical properties?

   _____

   _____

6. What elements would you expect to have similar chemical properties to fluorine (Fl)? Why?

   _____

   _____

7. Summarize: How do the periods and groups of the periodic table relate to the atomic numbers and chemical properties of the elements?

   _____

   _____

   _____

   _____