Teacher Guide: Element Builder

Learning Objectives

Students will…

- Compare the sizes, charges, and relative positions of the subatomic particles: protons, neutrons, and electrons.
- Relate an atom's number of protons to its charge, name, and atomic number.
- Calculate the mass number of an atom by summing the protons and neutrons.
- Understand the definition of isotope.
- Observe how electrons fill the first three energy levels.
- Create an electron dot diagram for each of the first 20 elements.

Vocabulary

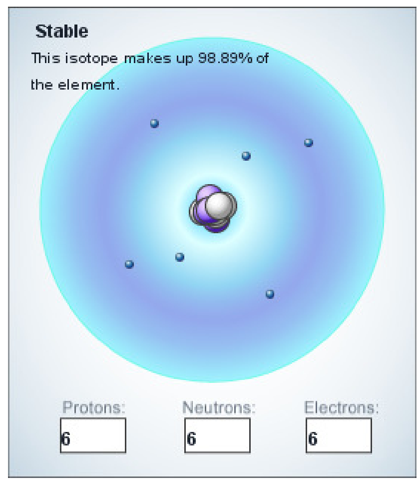
atom, atomic number, electron, electron dot diagram, element, energy level, ion, isotope, mass number, neutron, nucleus, periodic table, proton, radioactive, valence electrons

Lesson Overview

The *Element Builder* Gizmo™ allows students to construct atoms by adding protons, neutrons, and electrons. As they add particles, students can see the atomic number, mass number, charge, and electron dot diagram of the element.

The Student Exploration sheet contains two activities and an Extension:

- Activity A – Students determine the mass number and atomic number of an atom.
- Activity B – Students observe electron arrangements and create electron dot diagrams.
- Extension – Students see how valence electrons relate to the periodic table of elements.



Model of a carbon atom

Suggested Lesson Sequence

1. **Pre-Gizmo activity** (1 – 2 weeks)

   Atoms are too tiny to see, yet much about their structure had been deduced by the early part of the twentieth century. The development of atomic theory is one of the central narratives of physics and well worth learning more about.

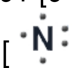
   Divide the class into groups and assign to each group one of the critical scientists involved in atomic theory. These could include Democritus, John Dalton, Dmitri Mendeleev, J.J. Thomson, Robert Millikan, Ernest Rutherford, Marie Curie, James Chadwick, Niels Bohr, Enrico Fermi, and others (see **Selected Web Resources**).

   After researching their scientist via the Internet, students can present their findings with posters, atom models, and even reenactments of famous experiments.

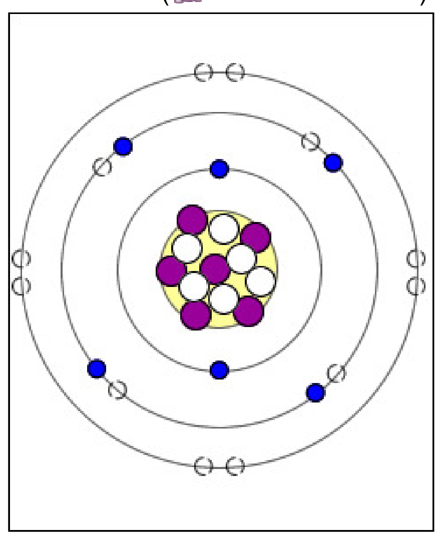
2. **Prior to using the Gizmo** (10 – 15 minutes)
Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (15 – 20 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:

    - How many protons and neutrons are in an atom of fluorine-19? [9 P, 10 N]
    - Draw an electron dot diagram for a neutral atom of nitrogen. []
    - Name three elements with one valence electron. [Hydrogen, sodium, potassium]
    - Helium, neon, and argon are all in a group called *noble gases*. What do you notice about their valence electrons? [Each has a full set of valence electrons.]

5. **Follow-up activity: Atom models** (45 – 60 minutes)
Have your students build atom models. To make an atom model, use a compass to draw 4 concentric circles on a sheet of white construction paper or cardstock. Cut out circles of colored construction paper to represent protons, neutrons, and electrons. (You can also use felt, cotton balls, or plastic disks for the particles.) On the three outer rings, draw empty circles in pairs to represent where electrons can be placed: 2 circles on the inner ring, 8 on the second, and 8 on the outermost ring.



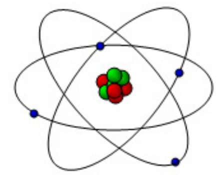
An atom model of carbon

Once students have constructed their models, they can model atoms of any element in the first three rows of the periodic table. Give the name of the element, the atomic number, and the mass number. Once students have placed the correct number of protons, neutrons, and electrons on their model, they can draw an electron dot diagram for that element. Students can also make ions with their model. To make a positively charged ion, remove electrons from the neutral atom. To make a negatively-charged ion, add electrons.

The same atom models will come in handy when you discuss chemical bonding. You can model an ionic bond by removing electrons from one model and adding them to another. For example, an electron can be removed from a sodium model and added to a fluorine model. This results in two ions that each have stable sets of 8 valence electrons. The positively charged sodium ion attracts the negatively charged fluorine atom, and an ionic bond forms. Covalent bonds can be demonstrated with these models as well.

Scientific Background

Atoms consist of three kinds of *elementary particles*: protons, neutrons, and electrons. Protons are positively charged and are located in the center, or *nucleus* of the atom. Neutrons have no charge and are also located in the nucleus. Electrons are negatively charged and orbit the nucleus in several bands, or *energy levels*. Protons and neutrons are about equal in mass (neutrons are slightly more massive), while electrons are about one thousandth the mass of a proton or neutron.



Simplified atom

Atoms can be described by several numbers. The *atomic* number (*Z*) is the number of protons in the atom. The atomic number also determines the element. For example, all oxygen atoms have 8 protons, while all gold atoms have 79 protons. The *mass number* (*A*) is the sum of protons and neutrons. Atoms of the same element with varying numbers of neutrons are called *isotopes*. Some isotopes are stable, while others are *radioactive*—they eventually break down and release particles or energy called *radiation*.

If an atom has the same number of protons and electrons, it is electrically neutral. If electrons are added or removed, the atom (now called an *ion*) becomes charged. Removing electrons from the atom results in a positively charged ion, called a *cation*. Adding electrons results in a negatively charged ion, also known as an *anion*.

Historical connection: Ernest Rutherford and the structure of the atom

Today the structure of the atom, with a central nucleus surrounded by whirling electrons, is taken for granted. But how was this structure discovered? A key experiment was done in 1909 by Ernest Rutherford, Hans Geiger, and Ernest Marsden. A sample of uranium was placed in a lead box with a small hole, emitting a beam of positively charged alpha particles. The beam of particles was directed at a thin sheet of gold foil only a few atoms thick. The foil was surrounded by a fluorescent detection screen that glowed briefly when struck by a charged particle.

At the time, the most popular atom model was the "plum-pudding" model of J.J. Thomson. In Thomson's model, negatively charged "plums" (electrons) were embedded in a positively charged "pudding." With this model in mind, Rutherford's team expected the alpha particles to pass through the foil with a very slight deflection. Instead, they found that while most of the alpha particles went through with *no* deflection, a few particles bounced right back!

Based on this surprising result, Rutherford's atom model consists of a dense, positively charged nucleus surrounded by a diffuse cloud of orbiting electrons. This model is still in use today.

Selected Web Resources

History of atomic theory: http://nobeliefs.com/atom.htm
Rutherford:
http://galileo.phys.virginia.edu/classes/252/Rutherford_Scattering/Rutherford_Scattering.html
Rutherford exp.: http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/ruther14.swf

Related Gizmos:
Electron Configuration: http://www.explorelearning.com/gizmo/id?513
Half-life: http://www.explorelearning.com/gizmo/id?369
Ionic Bonds: http://www.explorelearning.com/gizmo/id?514
Covalent Bonds: http://www.explorelearning.com/gizmo/id?512