Activity 4: Atomic Stability

Objectives

Students will learn what happens as atoms attempt to reach stability.

NOTE: Students should have a base knowledge in determining atomic structure (e.g., the atomic mass and atomic number of an atom based on the number of nucleons).

Next Generation Science Standards

The concepts in this activity can be used to support the following science standard:

- PS1. Structure and Properties of Matter.

Materials and Resources

- *Evolution of a Radioactive Atom: Teacher Background Information*.
- *Vocabulary Materials.*
- *Atomic Stability Worksheet* (one per student, pair or group) and *Atomic Stability Teacher Answer Key*.
- At least 21 objects per group (e.g., candy or small pieces of paper).
  - 10 objects should be the same color or marked with a plus (+) symbol to indicate they are protons.
  - 10 objects will represent neutrons with no electrical charge.
  - 1 object should be a different color or marked with a minus (-) symbol to indicate it is an electron.
- Student computers with Internet access (optional):
  - Radiation Basics, Types of Ionizing Radiation: http://www2.epa.gov/radiation/radiation-basics#tab-2
  - Radioactive Decay: http://www2.epa.gov/radiation/radioactive-decay

Time

45-60 minutes, not including optional activities or extensions.

Vocabulary

- Alpha particles
- Atom
- Beta particles
- Electron
- Ionizing radiation
- Neutron
- Nucleus
- Proton
- Radiation
- Radioactive atom
- Radioactive decay

Directions

1. Start with a vocabulary activity if students are not familiar with radiation and the terms used in this activity, or provide students with the terms and definitions.

2. Ask students to hypothesize:
   - Why some elements are radioactive (unstable). **When the atoms of an element have extra neutrons or protons it creates extra energy in the nucleus and causes the atom to become unbalanced or unstable.**
   - Whether radioactive elements can become stable and if so, how. **The unstable nucleus of radioactive atoms emit radiation. When this occurs, a new atom and element are formed. This process is called radioactive decay. It continues until the forces in the unstable nucleus are balanced.**

   NOTE: Images and videos demonstrating radioactive decay and alpha and beta emissions are available online if you would like to share them with students. Sources may include TeacherTube or other allowed Internet sources.

3. Distribute the *Atomic Stability Worksheet* and objects that represent protons, neutrons and an electron.

4. Explain that the focus of this activity will be on two types of radiation, alpha particles and beta particles, and how the release of alpha and beta particles changes the structure of the atom or nucleus. Pretend elements will be used in the activity to keep the number of nucleons small and manageable. Generally, the atoms of radioactive elements have a large number of nucleons.

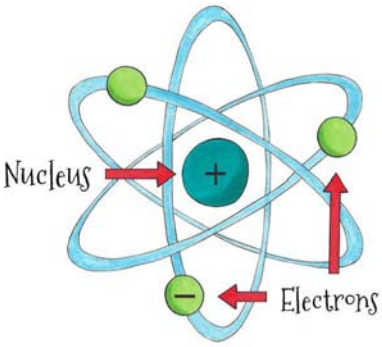
5. Guide students through the activity or perform the activity as a class if needed. Students should see that the emission of an alpha particle reduces the number of protons and neutrons by two. With the emission of a beta particle, the number of protons increases by one and the number of neutrons decreases by one.

6. Conclude by having students share what they learned about radioactive atoms the emission of alpha and beta particles.

7. Optional activity or extension: Ask students to:
   - Examine the properties, uses and health effects of alpha- and beta-emitters. Resources include:
   - Radiation Basics, Types of Ionizing Radiation: http://www2.epa.gov/radiation/radiation-basics#tab-2
   - Radioactive Decay: http://www2.epa.gov/radiation/radioactive-decay
   - Examine radioactive decay chains and determine whether each step was the result of an alpha or beta emission. See *Activity 6: Radioactive Decay Chain.*

Atomic Stability Worksheet

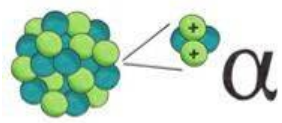
Name: _____ Date: _____



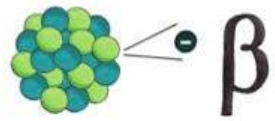
All elements are formed by atoms that are made up of:

- A nucleus containing protons and neutrons.
- Protons: positively (+) charged particles within the nucleus.
- Neutrons: particles within the nucleus that have no electrical charge (neutral).
- Electrons: particles that orbit the nucleus as a cloud and have a negative (–) charge.

The atoms of radioactive elements have an unstable nucleus. As the nucleus tries to become stable it releases energy (ionizing radiation) and extra protons or neutrons in the form of alpha or beta particles.



An **alpha particle** is made up of two protons (+2) and two neutrons from the atom's nucleus. Alpha particles have a positive charge (+2).



Before a **beta particle** is released a neutron changes into a proton and an electron (-1). The proton stays in the nucleus and the electron is released or ejected from the nucleus in the form of beta particles. Beta particles have a negative charge (-1).

Collect the materials and follow the directions to learn how the release of alpha and beta particles changes the structure of an atom.

Materials:

- 10 objects to represent neutrons.
- 10 objects to represent protons.
- 1 object to represent an electron.

1. Create a pretend radioactive nucleus for Element 1 including 5 neutrons (N) and 6 protons (P).

   Element 1 (N: 5, P: 6)

2. Demonstrate what happens to Element 1 when the pretend radioactive nucleus emits an alpha particle and a new element (Element 2) is formed. Then enter the number of neutrons and protons in the nucleus of Element 2.

   Element 1 (N: 5, P: 6)  Element 2 (N: , P:)

What differences do you observe between the number of protons and neutrons in Element 2 and Element 1?

_____

3. Return Element 2 to its original form: Element 1 (5 neutrons and 6 protons). Demonstrate what happens to Element 1 when it emits a beta particle and a new element (Element 3) is formed. Then enter the number of neutrons and protons in the nucleus of Element 3.

What differences do you observe between the number of protons and neutrons in Element 3 and Element 1?

_____

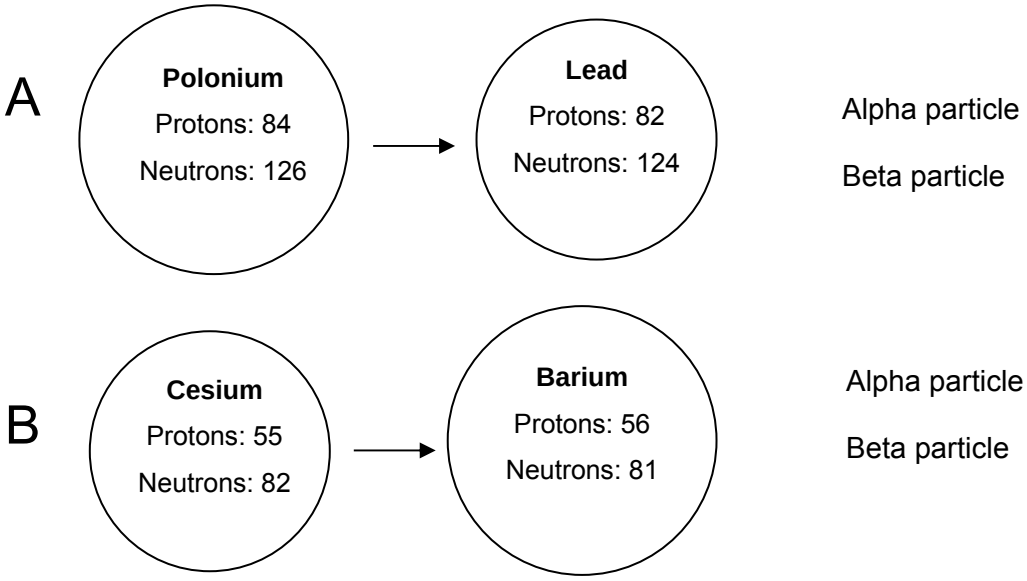
4. Every element has a different number of protons. What happens to unstable (radioactive) atoms when they release an alpha or beta particle and the number of protons change?

_____

_____

_____

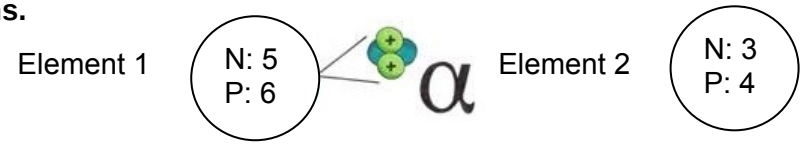
5. Observe the changes in the number of protons and neutrons between the two elements below. Determine whether examples A and B show the release of an alpha particle or a beta particle. Circle the correct answer.



Atomic Stability Teacher Answer Key

1. Create a pretend radioactive nucleus for Element 1 including 5 neutrons (N) and 6 protons (P).

2. Demonstrate what happens to Element 1 when the pretend radioactive nucleus emits an alpha particle and a new element (Element 2) is formed. Then enter the number of neutrons and protons in the nucleus of Element 2. **Students should remove two protons and two neutrons.**



   What differences do you observe between the number of protons and neutrons in Element 2 and Element 1? **When a radioactive atom releases an alpha particle, the number of protons and neutrons decreases by two.**

3. Return Element 2 to its original form: Element 1 (5 neutrons and 6 protons). Demonstrate what happens to Element 1 when it emits a beta particle and a new element (Element 3) is formed. Then enter the number of neutrons and protons in the nucleus of Element 3. **Students should change a neutron to a proton and an electron (-1). The proton stays in the nucleus and the electron is released or ejected from the nucleus in the form of beta particles.**

   What differences do you observe between the number of protons and neutrons in Element 3 and Element 1? **The release of a beta particle decreases the number of neutrons by one and increases the number of protons by one.**

4. Every element has a different number of protons. What happens to unstable (radioactive) atoms when they release an alpha or beta particle and the number of protons change? **When the release of energy changes the number of protons in the nucleus, the atoms transform into a new radioactive element. Radioactive atoms decay and transform into new elements until they become stable.**

5. Observe the changes in the number of protons and neutrons between the two elements below. Determine whether examples A and B show the release of an alpha particle or a beta particle. Circle the correct answer.
   A: Alpha particle. The number of protons and neutrons decrease by two.
   B: Beta particle. The number of protons increases by one and the neutrons decrease by one.