

**Title:** Isotopes and Radioactivity

**Author:** Marvin Pennell

**Subject Area(s):** Chemistry and Physics

**Grade(s):** 9-12

**Description of Lesson:** In this lesson, students will investigate the radioactive decay modes of various elements by means of an interactive computer software program.

**Length of Lesson:** 1 class period

**Student Objectives:** After completing this lesson, students will be able to:

- 1) describe various modes of radioactive decay such as alpha and beta ( $\beta^+$  and  $\beta^-$ )
- 2) predict the radioactive decay series for particular nuclides (via using the Chart of Nuclides)

**Materials:** access to computer lab

**Procedure:** In the computer lab or on your computer at home, go to the website:  
[www.nndc.bnl.gov/chart/](http://www.nndc.bnl.gov/chart/)

At first, it appears to look like a star galaxy. Instead, you are venturing into the website used around the world by the top researchers in the field of radioactivity. A chart of the nuclides will be seen on the screen. As stated on the top of the website, the Chart of Nuclides is a software product that allows to search and plot nuclear structure and nuclear data interactively. The software was developed by the National Nuclear Data Center (NNDC) in the Brookhaven National Laboratory. It provides an interface between users and several databases containing nuclear structure, nuclear decay, and some neutron-induced nuclear reaction information.

Navigating the chart may seem difficult at first until you learn some of the control steps. The chart can be seen with seven different zooming options. Let's look at the zooming level options first. With the largest zoom value, the entire chart is displayed. For smaller zoom values, only a fraction of the chart is displayed; the nucleus at the center of the viewing window is marked with a magenta border; neutron (horizontal axis) and proton numbers (vertical axis) are indicated. When the zoom level is equal to 1, the name of the nucleus, the ground state half-life, the two decay modes with the highest probability and its natural abundance are displayed.

Unless the zoom is at the largest value, clicking on a given nucleus also re-centers the chart. Further navigation possibilities can be obtained by using the arrows on the right-top corner of the window, as well as the 'Nucleus' textbox under the zoom control.

To use the chart, we need to know where to head based on the type of decay. Go to the top tool box and click on decay mode. This will bring up a color scheme as shown in the table below.

In the box that says nucleus, type in the chemical symbol, then a dash followed by the number (ex: U-235). Then press go and it will take you to the starting nuclide. Look at the decay type given in the box. Use the chart below to help you determine where to head for the next isotope. Once you land on that isotope, follow the same technique. If you have not clicked on **decay mode** on the top tool bar, you will not see the color scheme as shown in the chart.

Decay mode	Symbol	Color	Chart movement
alpha	$\alpha$	yellow	2 down, 2 left
beta	$\beta^-$	magenta	1 up, 1 left
positron	$\epsilon$	turquoise	1 down, 1 right

Other types of decay are shown but we will not go into them at this time.

### How to change this activity to follow more of our goals for this lesson:

Grid the floor of the classroom with electrical tape, streamers, or anything where you can make squares. Each square will now represent a nuclide.

Break the class into very small groups (2 to 3 students per group). Give them a small sign with a string around it (to place around their neck). The signs have an alpha, beta, or a positron symbol on it. If a student has a beta sign around their neck, their teammates must show them how to move among the grid system to the next nuclide. Do likewise for each different symbol. Make the students explain their motion on the gridded floor to each of their team members. This activity will help them understand the required motion when using the Chart of Nuclides.

**Scientific Explanation:** Many nuclei are radioactive; that is, they decompose, forming another nucleus and producing one or more particles. Radioactive nuclei can undergo decomposition in various ways such as alpha decay (helium nucleus), beta particle production, gamma rays, or positron production. All nuclides with 84 or more protons are unstable with respect to radioactive decay. Light nuclides are stable with the neutron/proton ratio is 1. There are also certain specific number of protons or neutrons that produce stable nuclides.

**Assessment:** Have the students perform the practice problem.

### Practice Problem

Let's practice using the uranium-235 decay series. Type in U-235 in the nucleus box and press go. Zoom in at level 1 or 2. Use the information in the table to find the half-life and radiation decay mode. In the chart, U-235 (your starting point) is already provided for you in the chart. Notice the predominant decay type is alpha, so count down two spaces and then move two spaces to the left. The spot that you now occupy is the next nuclide in the decay series. Fill in the nuclide, half-life, and primary mode of decay. The object is to continue until it reaches a stable nuclide (in this case, is Pb-207 as shown in **black which represents a stable nuclide**).



**Kansas Science Standards:**

*Standard 1, Benchmark 1: The student will demonstrate abilities necessary to do the processes of scientific inquiry.*

**Missouri Science Standards:**

Strand 7.1: Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking.