

Lesson Plan Excerpt for Atomic Nuclei

The Course: CP Physics/General Physics

This is a dual enrollment class. Students receive high school credit for College-Prep Physics, a class based on the new Ohio Revised Science Standards for Physics. Qualifying students also have the opportunity to enroll in PHYS-100 General Physics through Central Ohio Technical College for college credit; COTC has outlined Student Learning Outcomes for their course, which this class also meets.

Lessons: Atomic Nuclei (5 days)

State Standard: *“Alpha, beta, gamma and positron emission each have different properties and result in different changes to the nucleus. The identity of new elements can be predicted for radioisotopes that undergo alpha or beta decay. During nuclear interactions, the transfer of energy out of a system is directly proportional to the change in mass of the system as expressed by $E = mc^2$, which is known as the equation for mass-energy equivalence. A very small loss in mass is accompanied by a release of a large amount of energy. In nuclear processes such as nuclear decay, fission and fusion, the mass of the product is less than the mass of the original nuclei. The missing mass appears as energy. This energy can be calculated for fission and fusion when given the masses of the particle(s) formed and the masses of the particle(s) that interacted to produce them.”*

COTC Student Learning Objectives:

- 9.01 Explain the basic structure of the atom.
- 9.03 Describe radioactivity and radioactive decay.
- 9.04 Discuss the properties of alpha, beta, and gamma rays.
- 9.06 Define half-life.
- 9.07 Describe how to detect radiation.
- 9.08 Balance transmutation reactions.

Prior Learning Experience: The unit on nuclear atoms comes near the end of the course. We have previously covered mechanics, gravity, thermal energy, waves, electromagnetism, and light.

After a brief review of atomic theory (most physics students first encounter the development of this theory in CP Chemistry), we will focus on the nucleus. Five days devoted to this study of the atomic nucleus are described below.

Day 1 – Isotopes

- Mass spectrometer animation à isotopes
- Isotope nomenclature, atomic and mass numbers distinguished, average atomic mass
- Marble nuclei will be used to illustrate differences in isotopes. Students will be asked to model given isotopes, and to match symbols, names, marble models, and descriptions of given isotopes.

Day 2 – Strong Nuclear Force

- What does the neodymium magnet in the model represent? The strong nuclear force is described in terms of its dealers/feelers, magnitude, and range.

- The causes of nuclear stability are explored. The size of the nucleus might be detected as a factor by students from the marble model or from previous knowledge; neutron:proton ratio also discussed, as well as the limitations of the model.
- Chart of Nuclides introduced. Binding energy's role and the Valley of Stability.
- Half-Life Lab (pennies tossed to represent nuclei decaying)

Day 3 – Nuclear Radiation

- Discuss lab results.
- Chart of Nuclides show that different isotopes need to change in different ways to become stable. Types of radiation will be discussed.
- Students will write balanced transmutation equations.

Day 4 – Nuclear Reactions

- Fission is discussed, along with the changes in mass and energy that accompany it.
- Fusion is discussed, in laboratories and in stars, star life cycles, and processes that make elements heavier than iron.

Day 5 – Studying Nuclei

- Students will use the Fragmentation Box to explore nuclear collisions, the products of these collisions, and energy's role. They will record the isotopes made and discuss the stability of them.
- An overview of how NSCL produces rare isotope nuclei will be given, tying the way researchers use physics (especially mechanics and EM) to manipulate and study nuclei.
- The Chart of Nuclides will be revisited, and the ways and reasons researchers explore the edges of it will be discussed. Applications of nuclear physics will also be addressed.