Nuclear Equations

Unit: Atomic and Nuclear Physics

MA Curriculum Frameworks (2016): HS-PS1-8

AP® Physics 2 Learning Objectives: 5.C.1.1, 7.C.3.1

Mastery Objective(s): (Students will be able to…)

- Determine the products of α, $\beta-$, and $\beta+$ decay and electron capture.

Success Criteria:

- Equations give the correct starting material and products.

Language Objectives:

- Describe the changes to the nucleus during radioactive decay.

Tier 2 Vocabulary: decay, capture

Notes:

nuclear equation: a chemical equation describing the process of an isotope undergoing radioactive decay. For example:

$$^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$$

In a nuclear equation, the number of protons (atomic number) and the total mass (mass number) are conserved on both sides of the arrow. If you look at the bottom (atomic) numbers, and replace the arrow with an = sign, you would have the following:

92 = 90 + 2

Similarly, if you look at the top (mass) numbers, and replace the arrow with an = sign, you would have:

238 = 234 + 4

Use this space for summary and/or additional notes:

Sample problems:

Q: What are the products of beta-minus ($\beta-$) decay of $^{131}\mathrm{I}$?

A: A $\beta-$ particle is an electron, which we write as ${}^{0}_{-1}e$ in a nuclear equation. This means $^{131}\mathrm{I}$ decays into some unknown particle plus ${}^{0}_{-1}e$. The equation is:

$$^{131}_{53}\mathrm{I} \rightarrow {}^{m}_{p}X + {}^{0}_{-1}e$$

We can write the following equations for the atomic and mass numbers:

Atomic #s: $53 = p + -1 \rightarrow p = 54$; therefore X is Xe

Mass #s: $131 = m + 0 \rightarrow m = 131$

Therefore, particle X is ${}^{131}_{54}\mathrm{Xe}$ So our final answer is:

The two products of decay in this reaction are ${}^{131}_{54}\mathrm{Xe}$ and ${}^{0}_{-1}e$.

Q: Which particle was produced in the following radioactive decay reaction:

$$^{212}_{86}\mathrm{Rn} \rightarrow {}^{208}_{84}\mathrm{Po} + {}^{m}_{p}X$$

A: The two equations are:

Atomic #s: $86 = 84 + p \rightarrow p = 2$; therefore X is He

Mass #s: $212 = 208 + m \rightarrow m = 4$

Therefore, particle X is ${}^{4}_{2}\mathrm{He}$, which means it is an α particle.

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Homework Problems

For these problems, you will need to use a Figure CC. Periodic Table of the Elements (on page 623 of your Physics Reference Tables) and radioactive decay information from *Table EE. Selected Radioisotopes* on page 624 of your Physics Reference Tables.

Give the nuclear equation(s) for radioactive decay of the following:

1. **(M)** ^{222}Rn

2. **(M)** ^{85}Kr

3. **(S)** ^{220}Fr

4. **(S)** ^{37}K

5. **(S)** ^{3}H

Give the starting material for the following materials produced by radioactive decay:

6. **(M)** Alpha (α) decay resulting in $^{267}_{108}$Hs

7. **(M)** Beta-minus ($\beta-$) decay resulting in $^{185}_{75}$Re

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