Balancing Nuclear Reaction Equations

Why?

Nuclear reactions are going on all around us. Using correctly balanced equations is important when trying to understand nuclear reactions. All equations need to be balanced to conform to two conservation laws: the mass number is conserved, and the electrical charge is conserved.

Success Criteria

- Use the conservation laws to find an unknown in a nuclear reaction equation.
- Write a balanced nuclear equation for a natural transmutation.

Prerequisites

- atomic symbols including mass number, atomic number, and charge

Information

$_2^4He$ = a helium nucleus, also known as an alpha particle

$_{-1}^0e$ = an electron, also known as a beta particle when emitted by a nucleus

Model

The following are two nuclear reaction equations:

$$_{87}^{220}Fr \longrightarrow {}_2^4He + {}_{85}^{216}At$$

$$_7^{16}N \longrightarrow {}_{-1}^0e + {}_8^{16}O$$
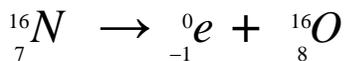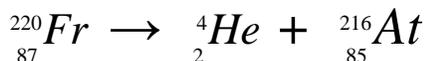
Key Questions

1. What are the products of francium-220 decay? Write the names of the products.

2. What are the products of nitrogen-16 decay? Write the names of the products.

3. (a) Is the alpha particle gained or released by the Fr-220?

   (b) Is the beta particle gained or released by the N-16?

4. (a) What is the mass number of an alpha particle?

   (b) What is the charge of an alpha particle?

5. (a) What is the mass number of a beta particle?

   (b) What is the charge of a beta particle?

6. By examining the equations in the model, what is the mathematical relationship between the total mass number of the reactants and the total mass number of the products? Show your work.

7. By examining the equations in the model, what is the mathematical relationship between the total charge in the nuclei of the reactants and the total charge of the nuclei in the products? Show your work. [Note: you are looking for the charge of the nuclei not the ionic charge on particles.]

8. How do your answers to Key Questions 6 and 7 support the laws of conservation of mass number and charge?

Exercises

1. Look at the equations in the model and explain what happens to the nucleus of each of the starting elements during the reaction.

2. Given the equation: $^{27}_{13}Al \; + \; ^{4}_{2}He \; \rightarrow \; ^{30}_{15}P \; + \; ^{1}_{0}n$

(a) How is this equation similar to the equations in the model?

(b) How is this equation different from the equations in the model?

3. Use the laws of conservation of mass number and charge to determine the identity of X in equations below. Refer to a periodic table as needed.

$$^{222}_{86}Rn \; \rightarrow \; ^{4}_{2}He \; + \; X$$

$$^{14}_{6}C \; \rightarrow \; ^{0}_{-1}e + \; X$$

$$X \; \rightarrow \; ^{0}_{+1}e + \; ^{19}_{9}F$$
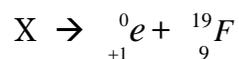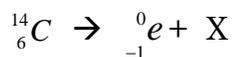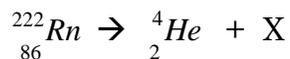
4. Write the balanced equation for the beta decay of Sr-90.

5. Below is a graph showing the number of neutrons versus the number of protons for all stable naturally occurring nuclei. (The solid line represents a neutron to proton ratio of 1:1.)
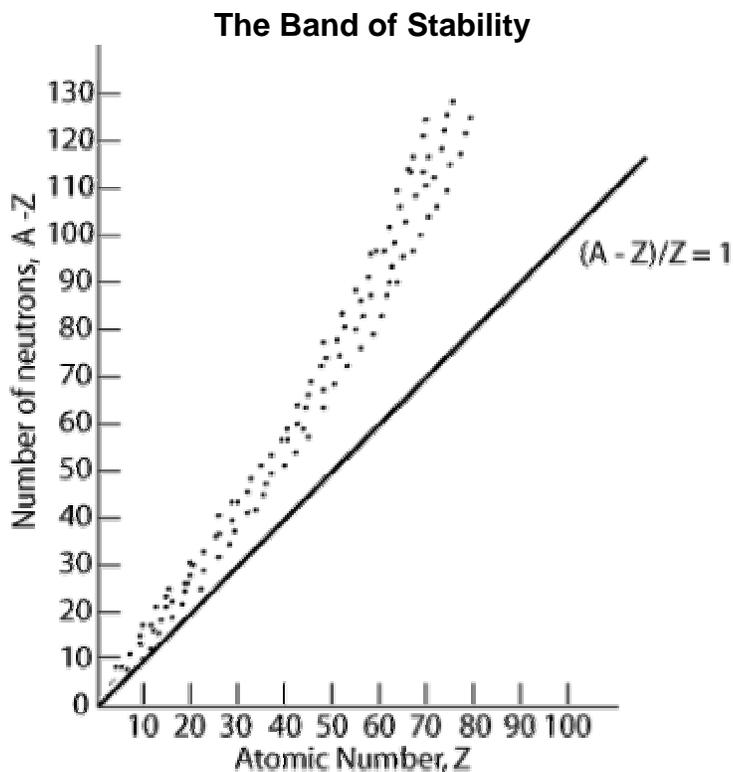
The Band of Stability

(a) Find the reactants from Exercises 3 and 4 on the graph. Where are they located on the graph in relation to the belt of stability?

(b) Are these reactants stable or do they decay spontaneously? Explain your answer.

Research

1. The change of U-235 to Pb-206 is used in the dating of geologic formations.
(a) Why is U-235 unstable? Use the information in Exercise 5 to provide an answer.

(b) Why is it possible to use this decay to date geologic formations?

2. If C-14 is constantly decaying, how is it that a living being has a constant amount of C-14 throughout its lifetime?