

Introduction to Physical Science

Nuclear Equations
Presented by Robert Wagner

Types of Particles in Nuclear Reactions

- Recall: Nuclear reactions involve changes in atomic numbers, mass numbers, or energy states of nuclei
- Particles:
 - Protons:
 - Neutrons:
 - Alpha Particles:
 - Beta Particles:
 - Positrons:

Types of Nuclear Reactions



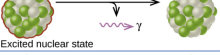

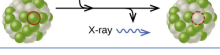
Type	Nuclear equation	Representation	Change in mass/atomic numbers
Alpha decay	${}^A_ZX \rightarrow {}^4_2\text{He} + {}^{A-4}_{Z-2}Y$		A: decrease by 4 Z: decrease by 2
Beta decay	${}^A_ZX \rightarrow {}^A_{Z+1}Y + {}^0_{-1}e$		A: unchanged Z: increase by 1
Gamma decay	${}^A_ZX \rightarrow {}^A_ZY + \gamma$		A: unchanged Z: unchanged
Positron emission	${}^A_ZX \rightarrow {}^A_{Z-1}Y + {}^0_{+1}e$		A: unchanged Z: decrease by 1
Electron capture	${}^A_ZX + {}^0_{-1}e \rightarrow {}^A_{Z-1}Y$		A: unchanged Z: decrease by 1

Image Credit: OpenStax Chemistry Figure 21.4 CC BY 4.0

Positrons

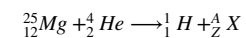
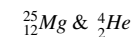
- Positron
 - Example of antimatter!
 - Like an electron but positively charged
- Matter and antimatter will annihilate each other
 - When an electron meets its antiparticle, they annihilate production gamma rays
 -
- Mass converted to energy
 - Can be calculated using:

Balancing Nuclear Reactions

- In chemical reactions, we had to make sure that the number of each atom remained the same
- In nuclear reactions, it is the number of nucleons that remains the same
- Two things to balance:
 - The sum of the mass numbers of the products is the same as the sum of the mass numbers of the reactants
 - The sum of the charges of the products is the same as the sum of the charges of the reactants

Example

- The reaction of an α -particle with magnesium-25 () yields a proton and the nucleus of another element. What is the nucleus produced?



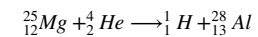
Balance mass number:

$$25 + 4 = 1 + A; 29 = 1 + A; A = 28$$

Balance charges:

$$12 + 2 = 1 + Z; 14 = 1 + Z; Z = 13$$

Z = 13 is aluminum



Example Nuclear Reactions from History (2)

- 1898: Marie Curie - first naturally occurring unstable element
 -
- 1919: Ernest Rutherford - first nuclide created artificially
 -
- 1932: James Chadwick - discovery of the neutron
 -

Example Nuclear Reactions from History

- 1937: Emilio Segre & Carlo Perrier - Produced technetium which does not occur naturally on Earth
 -
- 1942: University of Chicago - controlled nuclear chain reaction
 -

Summary

- Particles in nuclear reactions include nucleons - protons & neutrons. In addition, alpha particles (helium nuclei) and electrons and positrons can be involved
- Nuclear reactions are balanced by balancing the mass number and the electrical charge of the reactants and products
- We looked at several nuclear reactions that have been important in the history of nuclear chemistry