Balancing nuclear equations

Student activity • observation and reasoning

YEAR 11 / LESSON 94 / PHYSICS + SCIENCE (DOUBLE AWARD)

The question

Which numbers must balance when a nucleus changes?

Use nuclear-symbol cards to balance equations and identify the daughter nucleus.

Equipment

- Booklet, nuclear-symbol cards and periodic table

Paper equation models only. No radioactive substances or radiation detectors are used.

Course coverage: Shared Physics / Double Award: 7.7–7.8. Alpha, beta-minus, gamma and neutron emission; conserving nucleon number and charge.

Plan, model or apparatus sketch

Draw a labelled particle, nuclear-symbol or detector model appropriate to the task.

Method and reasoning

Read the whole sequence before starting

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1. Write a nucleus as A above Z at the left of its element symbol. For each equation add mass numbers and charge numbers separately on both sides.

2. Complete uranium-238, Z = 92, emitting an alpha particle with A = 4 and Z = 2. Find the daughter A and Z and identify thorium.

3. Complete carbon-14, Z = 6, undergoing beta-minus decay. Represent the emitted electron by A = 0 and charge number −1. Find the daughter and explain neutron-to-proton conversion.

4. Represent an excited nucleus emitting gamma radiation. Show no change in A or Z while energy is released. Distinguish this from no change at all in nuclear energy.

5. For an illustrative neutron-emission balance, let an excited nucleus have A = 15 and Z = 6. Emit a neutron with A = 1 and Z = 0, then calculate the daughter A and Z.

6. Check every equation independently for both sums. State that balancing numbers does not prove that an arbitrary reaction is energetically possible; the neutron case is a bookkeeping example.

Cleanup

- Collect cards and keep balanced equations.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Alpha emission changes A by −4 and Z by −2. Beta-minus changes A by 0 and Z by +1. Gamma changes neither; neutron emission changes A by −1 and Z by 0. The beta-minus school equation often omits the antineutrino, which has zero A and charge number.

Emission	Parent A / Z	Daughter A / Z	Check
Alpha	238 / 92		
Beta-minus	14 / 6		
Gamma	A / Z		
Neutron model	15 / 6		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Find the alpha daughter from uranium-238.

2. Find the beta-minus daughter from carbon-14.

3. Why does Z increase in beta-minus decay?

4. What changes in gamma emission?

5. Find A and Z after the stated neutron emission.

6. Does number balance alone prove a real decay occurs?