

Nuclear equations

4.4.2.2 · Atomic structure · revision notes

How to write and balance nuclear equations for alpha and beta decay, and how alpha, beta and gamma emission change the mass and charge of a nucleus. Expect 'complete the equation' questions and questions asking you to identify the type of decay from the numbers.

Key facts

- Alpha ${}^4_2\text{He}$: mass number – 4, atomic number – 2
- Beta ${}^0_{-1}\text{e}$: mass number unchanged, atomic number + 1
- Gamma ${}^0_0\gamma$: no change to mass number or atomic number
- Neutron ${}^1_0\text{n}$: mass number – 1, atomic number unchanged
- Top numbers balance; bottom numbers balance
- New atomic number = new element

Notes

Symbols in nuclear equations

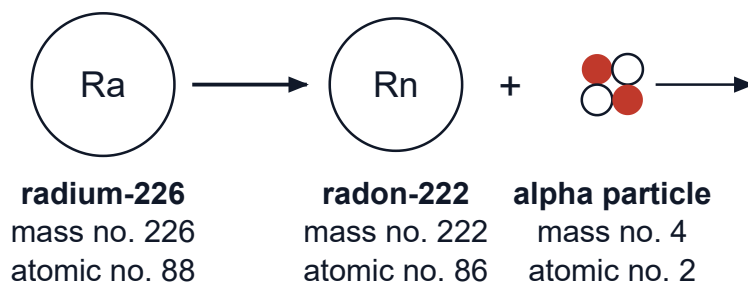
- Each nucleus is written as ${}^A_Z\text{X}$: A is the mass number and Z is the atomic number (its charge).
- Alpha particle: ${}^4_2\text{He}$ (sometimes written ${}^4_2\alpha$).
- Beta particle: ${}^0_{-1}\text{e}$ (sometimes written ${}^0_{-1}\beta$). Mass number 0, charge –1.
- Gamma ray: ${}^0_0\gamma$. Neutron: ${}^1_0\text{n}$

Balancing rules

- The mass numbers (top numbers) add up to the same total on both sides of the arrow.
- The atomic numbers (bottom numbers) add up to the same total on both sides.
- If the atomic number changes, the element changes. Use the new atomic number to find the new element.

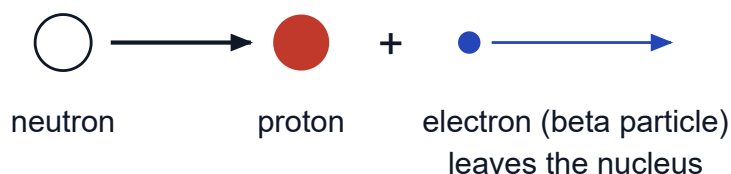
What each type of decay does

- Alpha decay:** mass number down by 4, atomic number down by 2. Both the mass and the charge of the nucleus decrease. Example: ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$



Alpha decay: mass numbers $226 = 222 + 4$ and atomic numbers $88 = 86 + 2$.

- Beta decay:** mass number unchanged, atomic number up by 1. The mass does not change but the charge increases, because a neutron has become a proton. Example: ${}^{90}_{38}\text{Sr} \rightarrow {}^{90}_{39}\text{Y} + {}^0_{-1}\text{e}$



Beta decay: a neutron becomes a proton plus an electron. Mass number unchanged; atomic number up by 1.

- Gamma emission:** no change to the mass or the charge of the nucleus. The nucleus just gets rid of energy, often straight after an alpha or beta decay.

How to answer each type of question

Describe how a decay changes the nucleus

2 marks

Grade 5

- For each decay, say what happens to the mass (mass number).
- Then say what happens to the charge (atomic number).

Example. Compare the effect on a nucleus of emitting an alpha particle and emitting a gamma ray.

Model answer. Alpha: the mass number decreases by 4 and the atomic number (charge) decreases by 2 (1). Gamma: there is no change to the mass or the charge of the nucleus (1).

Don't lose marks

- ✗ Writing the beta particle as ${}^0_1\text{e}$ or ${}^1_0\text{e}$. It is ${}^0_{-1}\text{e}$
- ✗ Taking 2 off the mass number in alpha decay. It is 4 off the mass number and 2 off the atomic number.

- ✗ Keeping the same element symbol after alpha or beta decay. The atomic number has changed, so the element has too.
- ✗ Thinking beta decay lowers the atomic number. It raises it by 1.

More tips

Memory tricks

- Alpha: 'minus 4, minus 2'. Beta: 'same, plus 1'. Gamma: 'no change'.
- Check every equation with two quick sums: the top numbers on each side, then the bottom numbers.
- The -1 on the beta particle is why the new nucleus goes UP by 1: the bottom numbers must still add up.

Exam technique

- Write both numbers for every particle in the equation, even if the question only asks for one.
- If a periodic table or list of elements is given, use the new atomic number to choose the symbol.
- When asked to 'describe' the change, use words too: e.g. 'the mass stays the same and the charge increases'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Recall the symbols for alpha and beta

Alpha is ${}^4_2\text{He}$ and beta is ${}^0_{-1}\text{e}$

Grade 5

State how alpha decay changes a nucleus

The mass number falls by 4 and the atomic number falls by 2.

Grade 5

State how beta decay changes a nucleus

The mass number stays the same and the atomic number goes up by 1.

Grade 5

Explain why gamma emission changes neither number

Gamma is electromagnetic radiation with no mass and no charge.

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