Nuclear Equations

Nuclear equations show radioactive decay and once you get the hang of them they're dead easy. Get going.

Mass and Atomic Numbers Have to Balance

1) Nuclear equations are a way of showing radioactive decay by using element symbols (p.174).
2) They're written in the form: atom before decay → atom after decay + radiation emitted.
3) There is one golden rule to remember: the total mass and atomic numbers must be equal on both sides.

Alpha Decay Decreases the Charge and Mass of the Nucleus

When a nucleus emits an alpha particle, it loses two protons and two neutrons, so:

- the mass number decreases by 4.
- the atomic number decreases by 2.

$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\alpha$$

mass number:	226	→	222	+ 4	(= 226)
atomic number:	88	→	86	+ 2	(= 88)

In both alpha and beta emissions, a new element will be formed, as the number of protons (atomic number) changes.

Beta-minus Decay Increases the Charge of the Nucleus

In a beta-minus decay, a neutron changes into a proton and an electron, so:

- the mass number doesn't change — as it has lost a neutron but gained a proton.
- the atomic number increases by 1 — because it has one more proton.

$$^{14}_{6}\text{C} \rightarrow {}^{14}_{7}\text{N} + {}^{0}_{-1}\beta$$

mass number:	14	→	14	+ 0	(= 14)
atomic number:	6	→	7	+ (-1)	(= 6)

Positron Emission Decreases the Charge of the Nucleus

In beta-plus decay, a proton changes into a neutron and a positron, so:

- the mass number doesn't change — as it has lost a proton but gained a neutron.
- the atomic number decreases by 1 — because it has one less proton.

$$^{18}_{9}\text{F} \rightarrow {}^{18}_{8}\text{O} + {}^{0}_{1}\beta$$

mass number:	18	→	18	+ 0	(= 18)
atomic number:	9	→	8	+ 1	(= 9)

Neutron Emission Decreases the Mass of the Nucleus

When a nucleus emits a neutron:

- the mass number decreases by 1 — as it has lost a neutron.
- the atomic number stays the same.

$$^{13}_{4}\text{Be} \rightarrow {}^{12}_{4}\text{Be} + {}^{1}_{0}\text{n}$$

mass number:	13	→	12	+ 1	(= 13)
atomic number:	4	→	4	+ 0	(= 4)

Gamma Rays Don't Change the Charge or Mass of the Nucleus

1) Gamma rays are a way of getting rid of excess energy from an atom. The nucleus goes from an excited state to a more stable state by emitting a gamma ray.
2) The mass and atomic numbers stay the same after a gamma ray has been emitted.

You can write gamma rays as $^{0}_{0}\gamma$.

Keep balanced during revision and practise nuclear equations...

Nuclear equations are simple, but that doesn't mean you shouldn't practise them. Try these questions on for size.

Q1 What type of radiation is given off in this decay? $^{8}_{3}\text{Li} \rightarrow {}^{8}_{4}\text{Be}$ + radiation. [1 mark]

Q2 Write the nuclear equation for $^{219}_{86}\text{Rn}$ decaying to polonium (Po) by emitting an alpha particle. [3 marks]

Nuclear Equations

Warm-Up

An isotope emits an alpha particle. Circle the correct options in the sentences below to describe how the isotope's atomic number and mass number changes.

The atomic number (increases / decreases) by (one / two).

The mass number (increases / decreases) by (one / four).

1 An electron is emitted from a nucleus. Grade 4-6

a) State the effect this has on the charge of the nucleus.

.....

[1]

b) After emitting the electron, the atom is excited. The atom releases its excess energy in the form of a gamma ray. Describe what, if any, effect this has on the charge and mass of the nucleus.

.....

[1]

[Total 2 marks]

2 A student writes down the following nuclear decay equation: $^{234}_{90}\text{Th} \longrightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{0}\gamma$ Grade 7-9

a) Explain why this equation must be incorrect.

.....

[1]

b) The student has missed out a particle from this decay equation.
Write down this particle as it would appear in a decay equation.

.....

[1]

c) Radium (Ra) has atomic number 88. The isotope radium-226 undergoes alpha decay to form radon (Rn). Write a nuclear equation to show this decay.

.....

[3]

d) The radon isotope then undergoes alpha decay to form an isotope of polonium (Po), which undergoes alpha decay to form an isotope of lead (Pb).
Calculate the number of neutrons in the nucleus of this lead isotope.

Number of neutrons = ...

[3]

[Total 8 marks]