Nuclear physics

OxfordAQA International GCSE Physics 9203, topic 3.7: the nuclear atom, radiations, decay equations, (P) half-life, fission, (P) fusion

A tiny nucleus

> The nucleus is a hundred-thousandth of the atom, yet holds nearly all its mass.

- OxfordAQA International GCSE Physics 9203, topic 3.7.
- (P) **half-life**, **contamination** and **fusion** are Paper 2.

Protons, neutrons, electrons

Particle	Relative mass	Charge
proton	1	$+1$
neutron	1	0
electron	almost 0	-1

Alpha scattering

> Most pass straight through: the atom is mostly empty.

- Rutherford's evidence for the nucleus.
- Mass and positive charge in a tiny centre.

Reading nuclear notation

Top: mass number. Bottom: proton number.

- Isotopes: same Z, different numbers of neutrons.
- neutrons $= A - Z$.

How far each radiation gets

Paper stops alpha, aluminium stops beta, lead reduces gamma.

- Decay is random: chemistry and heat cannot change it.
- Lead only reduces gamma; it never stops it completely.

Alpha, beta, gamma

Radiation	What it is	Ionising	Range in air
alpha	helium nucleus (2p + 2n)	strongest	a few cm
beta	fast electron	medium	tens of cm
gamma	EM wave	weakest	metres

Balancing a decay equation

1. **Equation** $^{210}_{84}\mathrm{Po} \to {}^{A}_{Z}\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$
2. **Top** $210 = A + 4$, so $A = 206$
3. **Bottom** $84 = Z + 2$, so $Z = 82$

Decision

The product is lead-206: $^{206}_{82}\mathrm{Pb}$.

(P) Half-life

> The count rate halves every 5.0 hours, whatever it starts at.

- Subtract the background count first.
- After two half-lives a quarter is left, not none.

(P) Contamination or irradiation?

Contamination

radioactive atoms on or in you

lasts until removed

Irradiation

exposure from outside

you do not become radioactive

Fission and the chain reaction

> Control rods leave one neutron per **fission** to cause the next.

- U-235 or Pu-239 absorbs a neutron and splits.
- Waste stays dangerous for many half-lives.

(P) Fusion

> Join two light nuclei: mass becomes energy.

- **Fusion** powers the stars.
- **Fission** splits heavy nuclei; fusion joins light ones.

Common mistakes

Mistake	Fix
A changes in beta decay	only alpha changes A (-4)
(P) two half-lives: all gone	a quarter is left
gamma worst inside the body	alpha: most ionising
irradiated means radioactive	only **contamination**

Check yourself

Question	**Answer**
Protons and neutrons in $^{19}_{9}\mathrm{F}$?	9 and 10
Stopped by paper?	alpha
Alpha decay of $^{226}_{88}\mathrm{Ra}$?	$^{222}_{86}\mathrm{Rn} + ^{4}_{2}\mathrm{He}$
What do control rods do?	absorb neutrons