

Radioactivity

Typed version of the handwritten AS Level Physics class notes (notebook pages 40 to 42). The original handwritten pages are on the same page of [megalecture.com](https://www.megalecture.com).

Q1. Rutherford's model and α-particle scattering

- The α-particle source was encased in metal with a small aperture, allowing a fine beam of α-particles to emerge.
- Air was pumped out to leave a vacuum; α-particles are absorbed by a few cm of air.
- Gold was chosen because it is malleable: it can be made into thin sheets.
- The α-particles were detected when they hit a solid "scintillating" material.

Most α-particles passed straight through, without being affected → most of the atom is empty space.

Some were backscattered → most of the mass of the atom is concentrated in a tiny space.

Particle	Mass	Charge
proton	1	+e
neutron	1	0
electron	0.0005	−e

Q2. Calculating the density of a proton

mass = 1.67×10^{-27} kg, radius = 0.8×10^{-15} m

volume = $\frac{4}{3} \pi r^3 = \frac{4}{3} \pi \times (0.8 \times 10^{-15})^3 = 2.14 \times 10^{-45} \text{ m}^3$

density = mass / volume = **$7.8 \times 10^{17} \text{ kg m}^{-3}$**

Assumptions: (1) the shape of the proton is spherical; (2) empty spaces are not considered.

Q3. What are isotopes?

Isotopes are nuclei of the same element, having the same number of protons but a different number of neutrons. Isotopes have the same chemical properties but different physical properties.

Q4. Ionising radiation

Ionisation is the loss or gain of electrons.

What is conserved: (1) nucleon number, (2) proton number, (3) mass-energy.

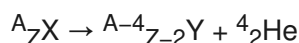
Particle	Mass	Charge	Speed	Penetration
α	4	+2e	106 m/s	paper



β	1/1840	$-e$	10^8 m/s	thin aluminium
γ	0	0	3×10^8 m/s	thick lead

An α -particle has a higher mass and charge, and is slower than β , so it is more likely to interact with any atom it passes and so is more likely to cause ionisation.

α decay



β decay

β^- : ${}_Z^AX \rightarrow {}_{Z+1}^AY + {}_{-1}^0e + \bar{\nu}$ (antineutrino). A neutron becomes a proton.

β^+ : ${}_Z^AX \rightarrow {}_{Z-1}^AY + {}_{+1}^0e + \nu$ (neutrino). A proton becomes a neutron.

Q5. Family of sub-atomic particles

- **Hadrons**: affected by the strong nuclear force.
 - **Baryons**: 3 quarks, e.g. protons (uud), neutrons (udd).
 - **Mesons**: 2 quarks.
- **Leptons**: not affected by the strong nuclear force, e.g. electrons.

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \quad \cdot \quad 1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$$

Checked by Mega Lecture

This typed version follows the handwritten notes. Two corrections: "most of the nucleus is empty space" is written as "most of the atom is empty space", and the first assumption in Q2 reads "the proton is spherical" (the notes say "atom"). The density calculation was rechecked and is correct. Spotted a mistake? Tell us on WhatsApp: +92 336 780 1123.