

11 Particle physics – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
deflection	_____	_____	_____
antiparticle	_____	_____	_____
positron	_____	_____	_____
neutrino	_____	_____	_____
hadron	_____	_____	_____
baryon	_____	_____	_____
meson	_____	_____	_____
lepton	_____	_____	_____

Recall

In **Part 1** you used the nuclear model (a tiny nucleus of protons and neutrons, with electrons around), proton and nucleon number, isotopes, the three radiations (α , β , γ) and quarks (proton = uud , neutron = udd). Part 2 adds the experiment that found the nucleus, writing decay equations, and the family of particles.

New ideas

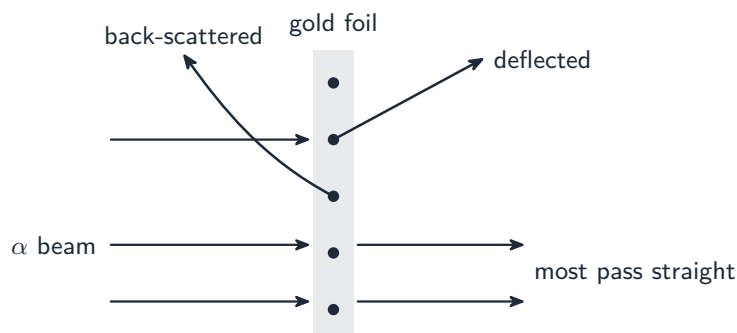
Read these first. Each idea has a short worked example. Then do the Practice.

■ 1 The α -scattering experiment

α -particles were fired at a thin gold foil. What was seen, and what it showed:

- **most passed straight through** $\rightarrow$ the atom is mostly empty space;
- a **few were deflected** through large angles (a strong **deflection**) $\rightarrow$ there is a tiny, dense, positively charged nucleus at the centre.

The nucleus ($\sim 10^{-15}$ m) is about 10^5 times smaller than the atom ($\sim 10^{-10}$ m).



Worked example. Of thousands of α -particles, nearly all pass straight through (the atom is mostly empty), and only about 1 in 8000 bounces back – showing the nucleus is tiny but very dense and charged.

■ 2 Writing decay equations

Two things are conserved: the **nucleon number** A (top) and the **charge / proton number** Z (bottom). So:

- α -decay: A drops by 4, Z drops by 2 – ${}^A_Z\text{X} \rightarrow {}^{A-4}_{Z-2}\text{Y} + {}^4_2\alpha$.
- β^- -decay: A stays, Z rises by 1 – ${}^A_Z\text{X} \rightarrow {}^A_{Z+1}\text{Y} + {}^0_{-1}\beta$.

Worked example. ${}^{238}_{92}\text{U}$ decays by α to ${}^{234}_{90}\text{Th}$; ${}^{14}_6\text{C}$ decays by β^- to ${}^{14}_7\text{N}$.



Watch out: in a decay equation the numbers must balance on *both* sides – the top numbers (A) total the same, and so do the bottom numbers (Z).

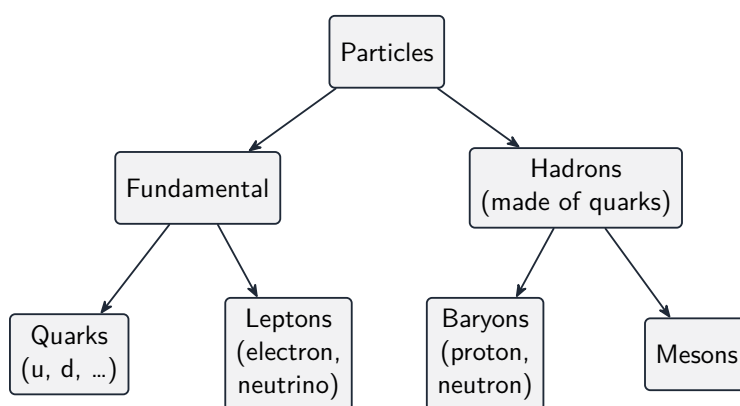
■ 3 Antiparticles and the particle families

Every particle has an **antiparticle** with the same mass but opposite charge; the **positron** is the electron's antiparticle. β -decay also gives out a tiny **neutrino** (or antineutrino).

Particles built from quarks are **hadron** particles:

- a **baryon** is three quarks – the proton and neutron are baryons;
- a **meson** is one quark + one antiquark.

A **lepton** (the electron, the neutrino) is **not** made of quarks. The truly *fundamental* particles are the **quarks** and **leptons**; protons and neutrons are not fundamental.



Worked example. A proton is uud – three quarks, so a baryon (a hadron). An electron contains no quarks, so it is a lepton, and fundamental.

Practice

11.1 In the α -scattering experiment, state what we learn from (a) most α -particles passing straight through, (b) a few deflecting through large angles. [2]

11.2 Radium-226, $^{226}_{88}\text{Ra}$, decays by α -emission. Write the nucleon and proton numbers of the daughter nuclide. [2]

11.3 Strontium-90, $^{90}_{38}\text{Sr}$, decays by β^- -emission. Write the nucleon and proton numbers of the daughter nuclide. [2]

11.4 State what a positron is, and its charge. [2]

11.5 State whether each is fundamental: (a) a proton, (b) an electron. [2]

11.6 Explain *how* the α -scattering result showed the nucleus is *positively* charged, not just small and dense. [2]

11.7 Challenge. Complete the α -decay $^{210}_{84}\text{Po} \rightarrow ?\text{Pb} + \alpha$: give the nucleon number and proton number of the lead nucleus. [2]