11 Particle physics – Part 2

Name: ______________ Class: __________ Date: ____________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
deflection	偏转			
antiparticle	反粒子			
positron	正电子			
neutrino	中微子			
hadron	强子			
baryon	重子			
meson	介子			
lepton	轻子			

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

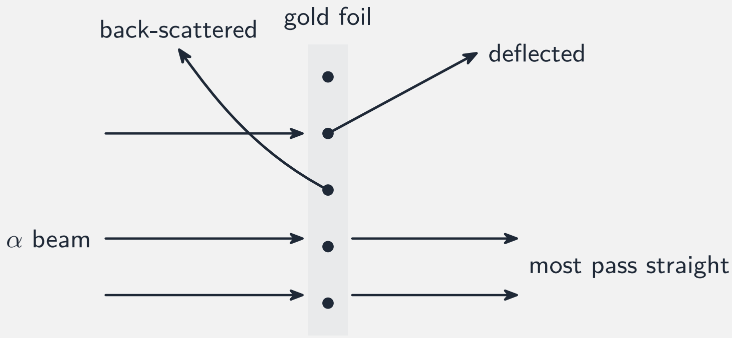
Read these first. Each idea has a short worked example. Then do the Practice.

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** → the atom is mostly empty space;
- a **few were deflected** through large angles (a strong **deflection** 偏转) → 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).



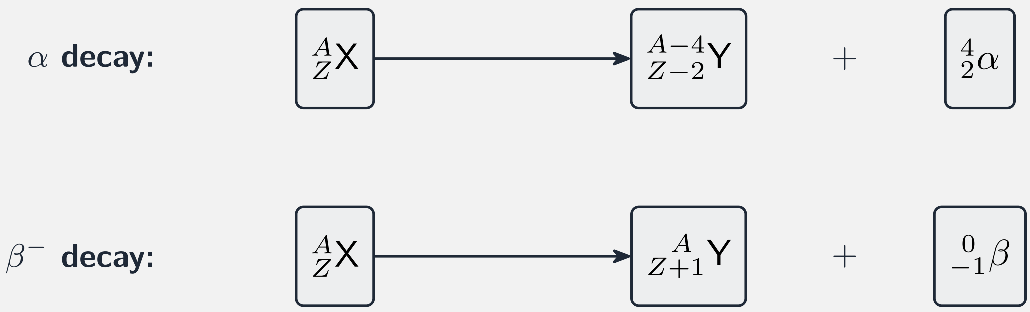
Worked example. Of thousands of α-particles, nearly all pass straight through (the atom is mostly empty), and only about 1 in 8000 bounces back —showing the nucleus is tiny but very dense and charged.

■ 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 —${}^{A}_{Z}\mathrm{X} \to {}^{A-4}_{Z-2}\mathrm{Y} + {}^{4}_{2}\alpha$.
- β^--decay: A stays, Z rises by 1 —${}^{A}_{Z}\mathrm{X} \to {}^{A}_{Z+1}\mathrm{Y} + {}^{0}_{-1}\beta$.

Worked example. ${}^{238}_{92}\mathrm{U}$ decays by α to ${}^{234}_{90}\mathrm{Th}$; ${}^{14}_{6}\mathrm{C}$ decays by β^- to ${}^{14}_{7}\mathrm{N}$.



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).

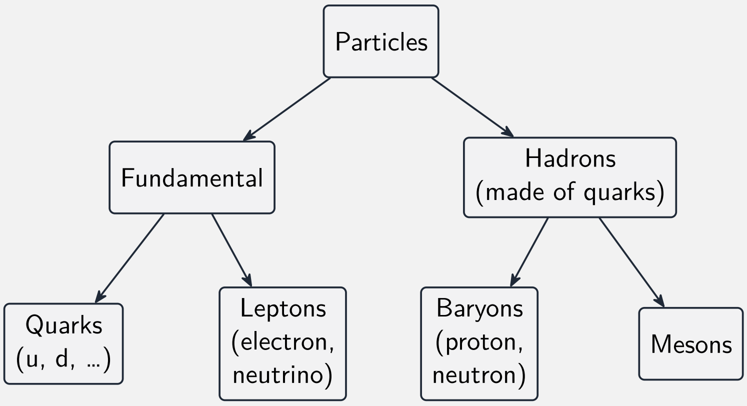
■ 3 Antiparticles and the particle families

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

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

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

A **lepton** 轻子 (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 ${}^{210}_{84}\mathrm{Po} \rightarrow {}^{?}_{?}\mathrm{Pb} + \alpha$: give the nucleon number and proton number of the lead nucleus. [2]