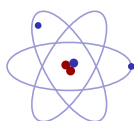


Nuclear Physics

IGCSE Physics ■ Topic 5

IGCSE Physics



Nuclear Physics

What we will cover

- 1 The nuclear atom
- 2 Nucleus, isotopes, fission & fusion
- 3 Radioactivity
- 4 Three types of radiation
- 5 Decay & half-life
- 6 Recap



1 The atom

Nuclear Physics

↳ The atom

The nuclear atom

A tiny positive **nucleus** 原子核 (protons and neutrons) holds nearly all the mass. Electrons orbit in shells.

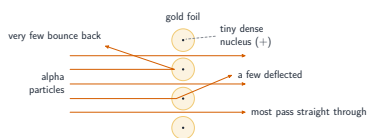
- proton number Z – the element
- nucleon number A – protons + neutrons

Isotopes 同位素 have the same Z , different A – same chemistry, different nuclear behaviour.

Nuclear Physics

↳ The atom

Alpha-scattering evidence



Alpha particles α 粒子 on gold foil:

- most pass straight $\rightarrow$ mostly empty
- a few deflect $\rightarrow$ positive nucleus
- a very few bounce back $\rightarrow$ tiny, heavy nucleus

Nuclear Physics

↳ The atom

Inside the nucleus

Nucleons 核子: **protons** 质子 (+1) and **neutrons** 中子 (0). Notation ${}_Z^AX$.

- Z = proton number; A = nucleon number; neutrons = $A - Z$
- **isotopes** 同位素: same Z , different A



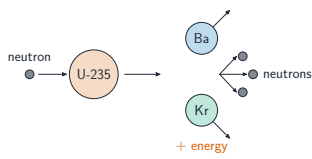
carbon-12
6 protons, 6 neutrons



carbon-14
6 protons, 8 neutrons

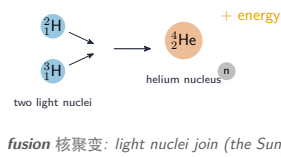
● proton
● neutron

Fission and fusion



fission 核裂变: a heavy nucleus splits

Both lose a little mass, turned into energy; the A and Z numbers balance on each side.



fusion 核聚变: light nuclei join (the Sun)

2 Radioactivity

Radioactivity

An **unstable** 不稳定 nucleus **decays** 衰变, giving out radiation. Decay is **spontaneous** and **random**. **Background radiation** 背景辐射 (radon, rocks, cosmic rays) is always present – subtract it:

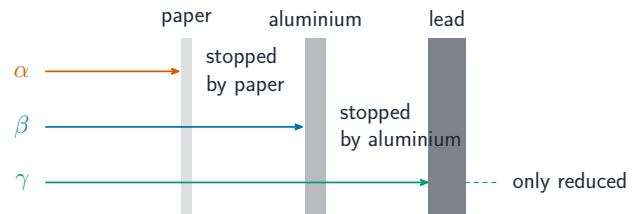
250 next to source, 30 background

corrected = 220 counts/min



Three types of radiation

- α – He nucleus (+2): most **ionising** 电离, stopped by paper
- β – fast electron (–1): aluminium
- γ – EM wave (0): least ionising, only reduced by lead



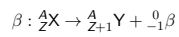
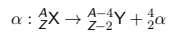
Deflection in fields

Charged α and β bend **opposite** ways; the lighter β bends more. Uncharged γ is **not** deflected.

α is ${}^4_2\text{He}^{2+}$; β is an electron (or positron); γ is a photon. Charge and mass decide the bend.

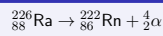
3 Decay and half-life

Decay equations

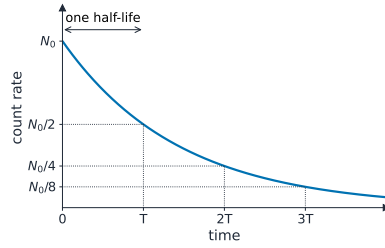


γ emission: only energy leaves, A and Z unchanged.

${}^{226}_{88}\text{Ra}$ emits α



Half-life



Half-life 半衰期: the time for half the unstable nuclei (or the count rate) to halve.

800 $\rightarrow$ 100 **counts/min**,
 $T = 5$ days

three halvings $\Rightarrow$ 15 days

Uses and safety

Match the source to the job:

- smoke alarms – α
- **sterilising** 消毒 – penetrating γ
- thickness gauge – β

Lower the **dose** 剂量: less **time**, more **distance**, **shielding** 屏蔽 (lead).

Handle with tongs; store in a lead box.

4

Recap

Topic 5 – key takeaways

1 Nucleus

A_ZX ; isotopes share Z

2 Radiation

α (paper), β (Al), γ (lead)

3 Decay

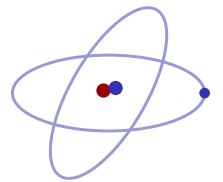
A & Z balance; α , β , γ

4 Half-life

count rate halves each half-life

Check yourself

- 1 How many neutrons in ${}^{197}_{79}\text{Au}$?
- 2 Which radiation is stopped by paper?
- 3 ${}^{24}_{11}\text{Na}$ emits β – the new proton number?
- 4 After 2 half-lives, what fraction is left?



Answers 1. $197 - 79 = 118$ 2. alpha 3. 12 4. one quarter