

11 Particle physics – Part 1

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)		
nucleus	原子核	_____	_____	_____
proton	质子	_____	_____	_____
neutron	中子	_____	_____	_____
nucleon	核子	_____	_____	_____
proton number	质子数	_____	_____	_____
nucleon number	核子数	_____	_____	_____
isotope	同位素	_____	_____	_____
radioactive	放射性	_____	_____	_____
radiation	辐射	_____	_____	_____
quark	夸克	_____	_____	_____

Recall

At IGCSE you met the atom. Bring this with you:

- An atom has a tiny central **nucleus** 原子核 with electrons around it.
- The nucleus holds **proton** 质子 (positive) and **neutron** 中子 (no charge) particles.

At AS we count these particles exactly and look at what protons and neutrons are made of.

New ideas

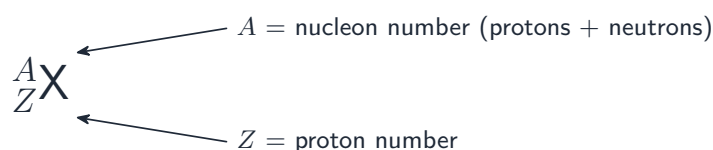
Read these first. Each idea has a short worked example. Then do the Practice.

■ 1 Counting the nucleus

A proton and a neutron are both **nucleon** 核子 particles. We label a nucleus ${}^A_Z\text{X}$:

- the **proton number** 质子数 Z = number of protons (it decides which element it is);
- the **nucleon number** 核子数 A = total protons + neutrons, so neutrons = $A - Z$.

Atoms of one element with different neutron numbers are **isotope** 同位素 forms of it (same Z , different A).

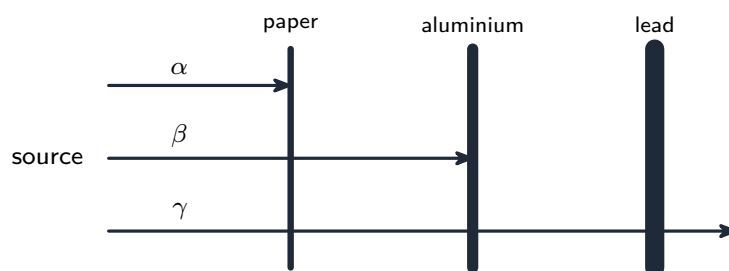


Worked example. Carbon-14 is ${}^{14}_6\text{C}$: $Z = 6$ protons, and $A - Z = 14 - 6 = 8$ neutrons.

Watch out: the proton number Z decides the *element*. Change only the neutron number and you get an *isotope* of the same element — not a new element.

■ 2 Radioactivity

Some nuclei are unstable and **radioactive** 放射性: they give out **radiation** 辐射 to become more stable. There are three kinds — alpha (α), beta (β) and gamma (γ). Alpha is stopped by paper, beta by thin metal, and gamma is the most penetrating.



Worked example. To identify a source: if paper stops it, it is alpha; if it passes paper but a few mm of aluminium stops it, it is beta; if even thick lead only reduces it, it is gamma.

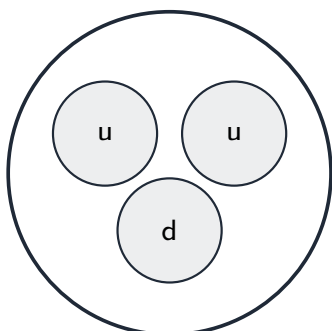
■ 3 Inside protons and neutrons

Protons and neutrons are not the smallest particles — each is built from three **quark** 夸克 particles (the "up" quark u with charge $+\frac{2}{3}$, and the "down" quark d with charge $-\frac{1}{3}$):

- proton = uud ,

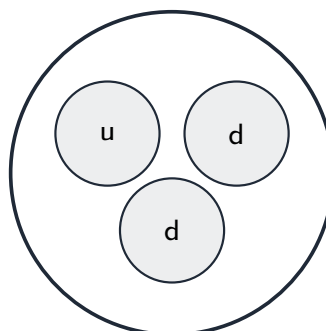
- neutron = $u d d$.

proton (charge +1)



$$+\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = +1$$

neutron (charge 0)



$$+\frac{2}{3} - \frac{1}{3} - \frac{1}{3} = 0$$

Worked example. Adding the quark charges in a proton: $+\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = +1$ — the proton's charge. For a neutron: $+\frac{2}{3} - \frac{1}{3} - \frac{1}{3} = 0$.

Practice

11.1 A nucleus is written ${}_{11}^{23}\text{Na}$. State (a) the number of protons, (b) the number of neutrons. [2]

11.2 Explain what is meant by two isotopes of an element. [2]

11.3 State the quark content of (a) a proton, (b) a neutron. [2]

11.4 Put alpha, beta and gamma radiation in order, from least to most penetrating. [1]

11.5 Explain *why* an alpha source is fairly safe outside the body but dangerous if swal-

lowed.

[2]

11.6 Challenge. Using the quark charges $u = +\frac{2}{3}$ and $d = -\frac{1}{3}$, show that a proton (uud) has charge $+1$ and a neutron (udd) has charge 0 . [2]