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

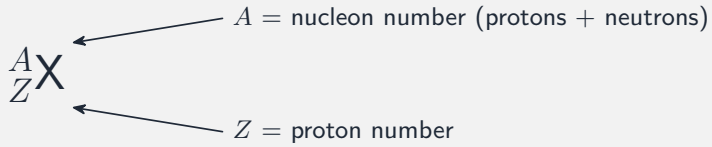
Read these first. Each idea has a short worked example. Then do the Practice.

1 Counting the nucleus

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

- 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).

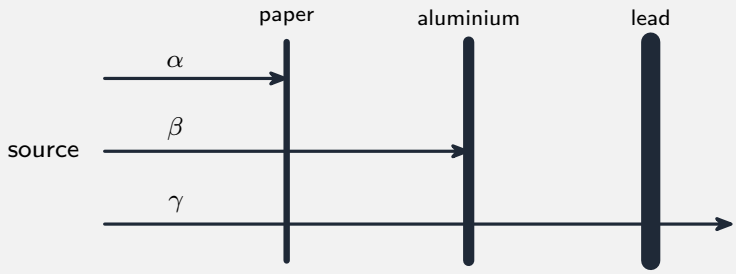


Worked example. Carbon-14 is ${}^{14}_{6}\mathrm{C}$: $Z = 6$ protons, and $A - Z = 14 - 6 = 8$ neutrons.

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.



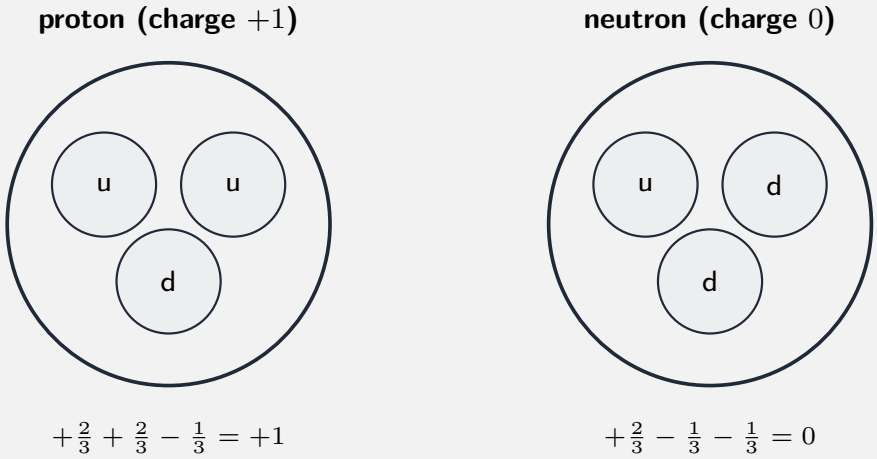
Worked example. To identify a source: if paper stops it, it is alpha; if it passes paper but a few mm of aluminium stops it, it is beta; if even thick lead only reduces it, it is gamma.

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 = $u\,u\,d$,

- neutron $= u\,d\,d$.



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

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 $^{23}_{11}\mathrm{Na}$. 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]