

11 Particle physics – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
nucleus	_____	_____	_____
proton	_____	_____	_____
neutron	_____	_____	_____
nucleon	_____	_____	_____
proton number	_____	_____	_____
nucleon number	_____	_____	_____
isotope	_____	_____	_____
radioactive	_____	_____	_____
radiation	_____	_____	_____
quark	_____	_____	_____

Recall

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

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

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

New ideas

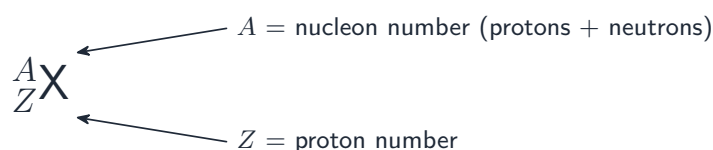
Read these first. Each idea has a short worked example. Then do the Practice.

■ 1 Counting the nucleus

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

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

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

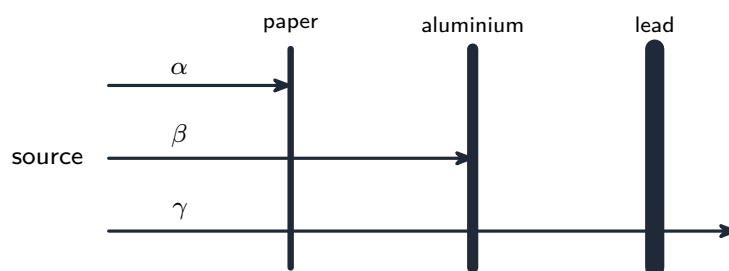


Worked example. Carbon-14 is ${}^{14}_6\text{C}$: $Z = 6$ protons, and $A - Z = 14 - 6 = 8$ neutrons.

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** : they give out **radiation** 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.

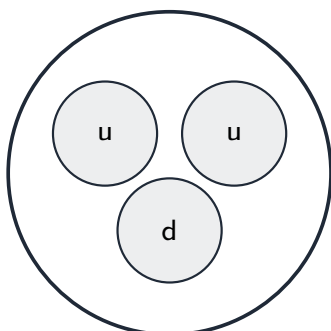
■ 3 Inside protons and neutrons

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

- proton = uud ,

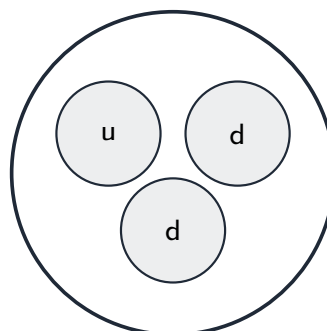
- neutron = $u d d$.

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 swallowed. [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]
