

Inside the Atom: Protons, Neutrons and Electrons

What are protons, neutrons and electrons?

●○○ Beginner

Atomic Structure & Periodicity

Last reviewed 3 October 2026

What is it?

Every atom is built from three kinds of particle:

Particle	Charge	Mass (approx.)	Where it is
Proton (p^+)	+1	1 u	In the nucleus
Neutron (n)	0	1 u	In the nucleus
Electron (e^-)	-1	about 1/1836 of a proton	Around the nucleus

The **nucleus** is a tiny, dense centre containing the protons and neutrons. The electrons occupy the much larger space around it.

KEY IDEA

The number of **protons** decides which element an atom is. Every carbon atom has 6 protons; any atom with 6 protons is carbon.

Why does it matter?

The arrangement of these particles explains almost everything in chemistry:

- **Protons** give each element its identity and its place in the periodic table.
- **Electrons** take part in chemical reactions and bonding, so they decide how an element behaves.
- **Neutrons** help hold the nucleus together and explain why atoms of the same element can have different masses (isotopes), which matters in fields such as radiocarbon dating and medical imaging.

How does it work?

1. Atomic number and mass number

- **Atomic number** (Z) = number of protons.
- **Mass number** (A) = number of protons + number of neutrons.
- So the number of neutrons = $A - Z$.

These are written as a **nuclide symbol**, with the mass number at the top left and the atomic number at the bottom left:



Sodium-23 has 11 protons and $23 - 11 = 12$ neutrons.

2. Neutral atoms and ions

In a **neutral atom**, the number of electrons equals the number of protons, so the charges cancel.

An **ion** forms when an atom gains or loses **electrons** (never protons):

- Losing electrons gives a **positive** ion (cation): Na^+ has 11 protons and 10 electrons.
- Gaining electrons gives a **negative** ion (anion): Cl^- has 17 protons and 18 electrons.

3. Isotopes

Isotopes are atoms of the same element (same number of protons) with **different numbers of neutrons**, and therefore different mass numbers:

Isotope	Protons	Neutrons
Carbon-12	6	6
Carbon-13	6	7
Carbon-14	6	8

Isotopes of an element have essentially the same chemical properties, because they have the same number of electrons.

THINK OF IT LIKE THIS

If an atom were the size of a large sports stadium, its nucleus would be about the size of a small marble at the centre, yet it would hold almost all of the stadium's mass. The rest of the "stadium" is the space where the electrons are found.

MORE PRECISELY

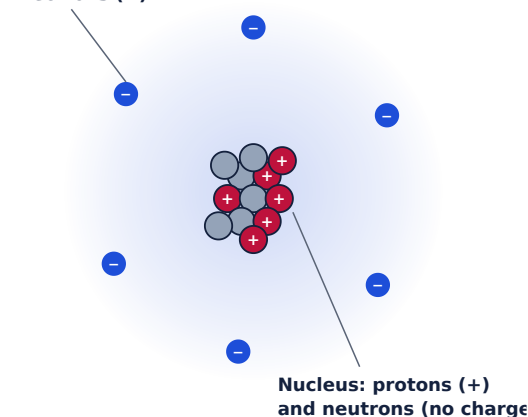
A proton (1.007 u) and a neutron (1.009 u) are not exactly 1 u, and the electron's mass is about 0.000549 u. Electrons don't travel in neat circular orbits like planets. Quantum mechanics describes them by **orbitals**, regions where an electron is likely to be found. Protons and neutrons are themselves made of smaller particles called quarks, which is beyond what chemistry needs here.

Visualise it

A carbon-12 atom

6 protons, 6 neutrons, 6 electrons

Electrons (-)



Shading shows where electrons are likely to be.

Not to scale: the real nucleus is tens of thousands of times smaller than the atom.

A carbon-12 atom (not to scale).

Worked example

✎ WORKED EXAMPLE: Counting particles in an ion

Question: How many protons, neutrons and electrons are in the ion ${}^{56}_{26}\text{Fe}^{3+}$?

Step 1 Protons = atomic number = **26**

Step 2 Neutrons = $A - Z = 56 - 26 = \mathbf{30}$

Step 3 A charge of 3+ means 3 electrons have been lost: $26 - 3 = \mathbf{23}$ electrons

✎ WORKED EXAMPLE: Writing the symbol from particle counts

Question: A particle has 17 protons, 20 neutrons and 18 electrons. Write its symbol.

Step 1 17 protons means the element is chlorine ($Z = 17$).

Step 2 Mass number = $17 + 20 = 37$.

Step 3 18 electrons is one more than 17 protons, so the charge is 1-.

Answer: ${}^{37}_{17}\text{Cl}^{-}$, a chloride ion of chlorine-37.

Common mistake

COMMON MISTAKE: Changing protons to make an ion

Ions form by gaining or losing **electrons**. If the number of protons changed, it would be a different element.

COMMON MISTAKE: Finding neutrons from electrons

Neutrons = mass number – **protons** (atomic number), not mass number – electrons. For ions the two give different answers.

COMMON MISTAKE: Confusing mass number with atomic mass

The **mass number** is a whole-number count of protons and neutrons in one particular isotope (chlorine-35 has $A = 35$). The **atomic mass** on the periodic table ($\text{Cl} = 35.45$) is an *average* over the element's naturally occurring isotopes, so it is usually not a whole number.

NOTATION NOTE

- An isotope can be written in several ways: $^{14}_6\text{C}$, ^{14}C , carbon-14, or C-14. The atomic number is often left out because the symbol already tells you the element.
- The particles inside the nucleus (protons and neutrons) are together called **nucleons**.
- “u” (unified atomic mass unit) is also written amu or Da (dalton).

Remember this

REMEMBER THIS

- Protons (+) and neutrons (0) are in the nucleus; electrons (–) are around it.
- Atomic number Z = protons; mass number A = protons + neutrons.
- Ions: change the number of **electrons**, never protons.
- Isotopes: same element, different numbers of neutrons.

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

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