Atoms

Printable revision sheet — Galaxscia

LEVEL 1

The basics of matter

The matter around us – such as air, water or our own body – is made of molecules. But looking more closely, we find that these molecules are themselves made of even smaller particles: atoms.

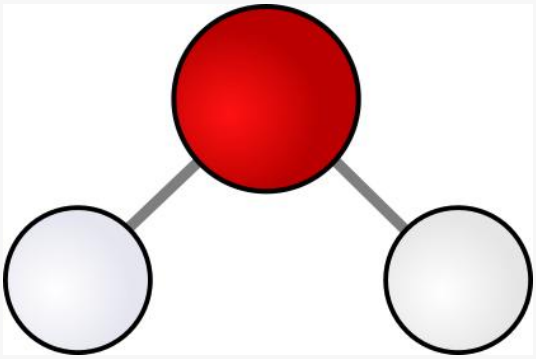
Imagine a lump of sugar cut in two, then in two again, and so on for ever. At the end of the process you would be left with atoms: the fundamental "building blocks" of all matter.

Dalton's model: spheres to represent atoms

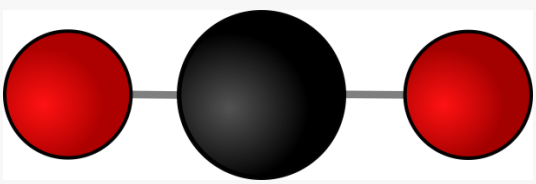
At the start of the 19th century, John Dalton put forward a simple model: each atom is a small solid sphere. When several of these spheres bond together, they form a molecule.

Examples:

A water molecule = 2 hydrogen atoms + 1 oxygen atom



A carbon dioxide molecule = 1 carbon atom + 2 oxygen atoms



The colours used to represent atoms in models are not real, but they help to tell them apart visually.

The 4 star atoms of living things

Out of more than 100 different types of atom, 4 are very common in biological molecules:

Carbon (C)

Hydrogen (H)

Oxygen (O)

Nitrogen (N)

Each one is represented by a chemical symbol: a capital letter, sometimes followed by a lower-case one.

Chemical formulas

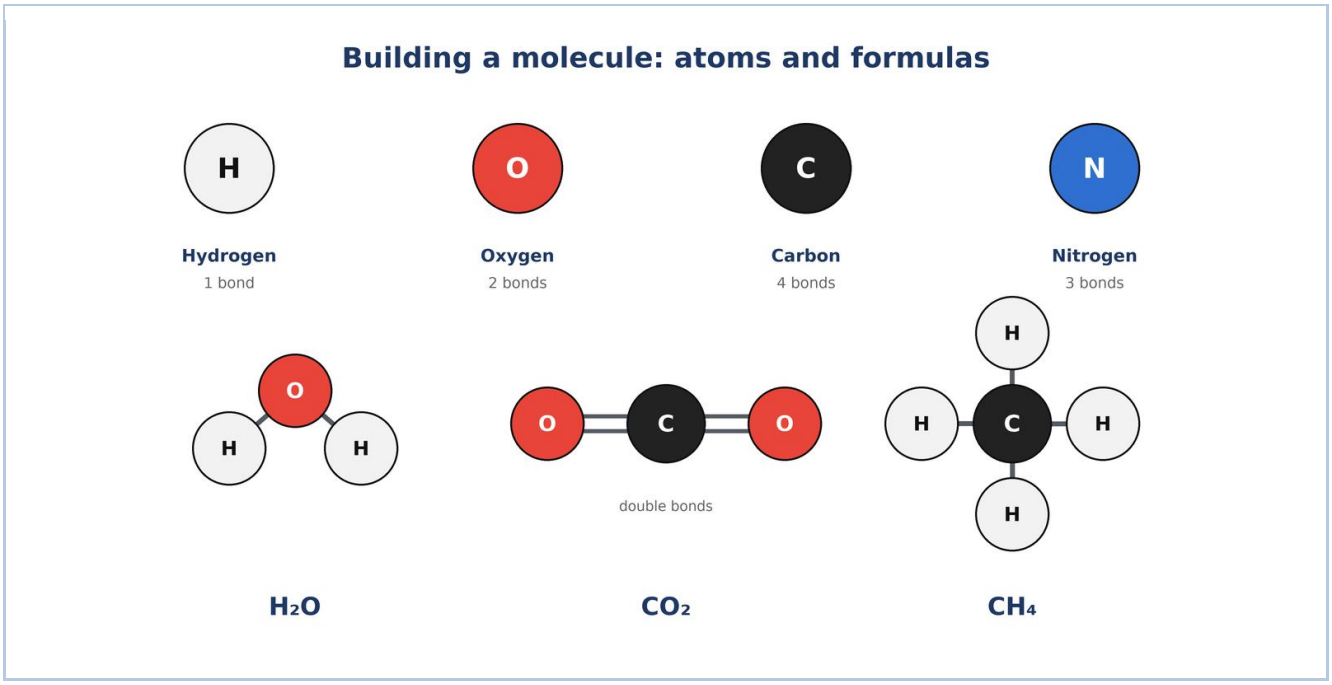
So, using the symbol of each atom, we can write the chemical formula of a molecule to give its composition. We write the symbol of the atom followed, as a subscript, by the number of those atoms in the molecule.

Note that when there is only one atom, the 1 is not written, to keep the notation light.

Example

For water, which has 2 hydrogen atoms and one oxygen atom, this gives H_2O

For carbon dioxide, which has 2 oxygen atoms and 1 carbon atom, the formula is: CO_2



A bit of history

The word "atom" comes from the ancient Greek *atomos*, which means "indivisible". The ancient Greeks had already imagined this idea around 400 BC. It was then forgotten for centuries, before being confirmed by scientific experiments in the 19th century.

Key points — revision questions

- What is matter made of?
- What is a molecule?
- How can an atom be modelled simply?
- Which are the 4 atoms most used in chemistry?
- What colour code is used for these atoms?

LEVEL 2

Rutherford's experiment: a revolutionary model

At the start of the 20th century, the physicist Ernest Rutherford carried out a landmark experiment. He fired particles at a thin sheet of gold. To his great surprise, most went straight through the sheet, but some were deflected or bounced back. This means the atom is not a solid sphere!

Rutherford's model

The atom is made up of:

a nucleus, very small, positively charged, where almost all the mass is concentrated,

an electron cloud containing electrons, very light and negatively charged, which move around the nucleus,

The atom is therefore mostly empty space between the nucleus and the electrons: we speak of a mostly empty structure.

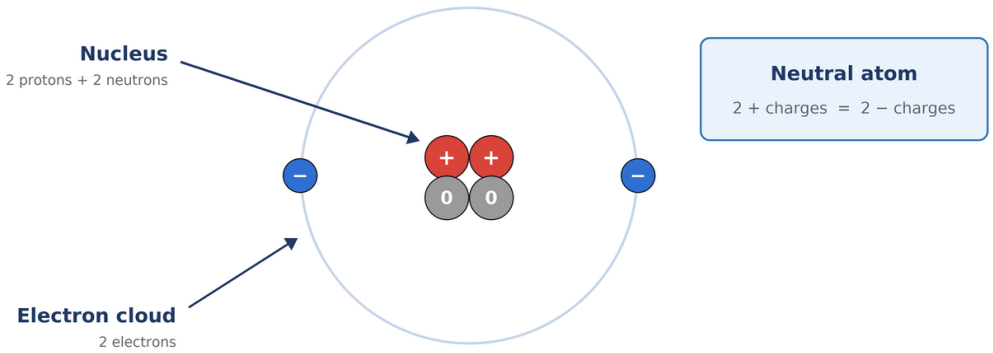
The balance of charges: electrical neutrality

An atom is electrically neutral overall:

the number of positive charges (protons) = the number of negative charges (electrons)

If an atom loses or gains electrons, it becomes an ion (positive or negative).

Rutherford's model: nucleus, electrons and empty space



Almost all the volume of the atom is empty space.

Key points — revision questions

- What is an atom made of?
- What is the electric charge of an atom?

LEVEL 3

The nucleus: protons and neutrons

The nucleus is made of nucleons:

protons, positively charged,

neutrons, with no charge, which make the nucleus stable.

Atomic notation:

An atom is written in the following way:

AZX

X: symbol of the atom

Z: atomic number = number of protons

A: mass number = number of nucleons (protons + neutrons)

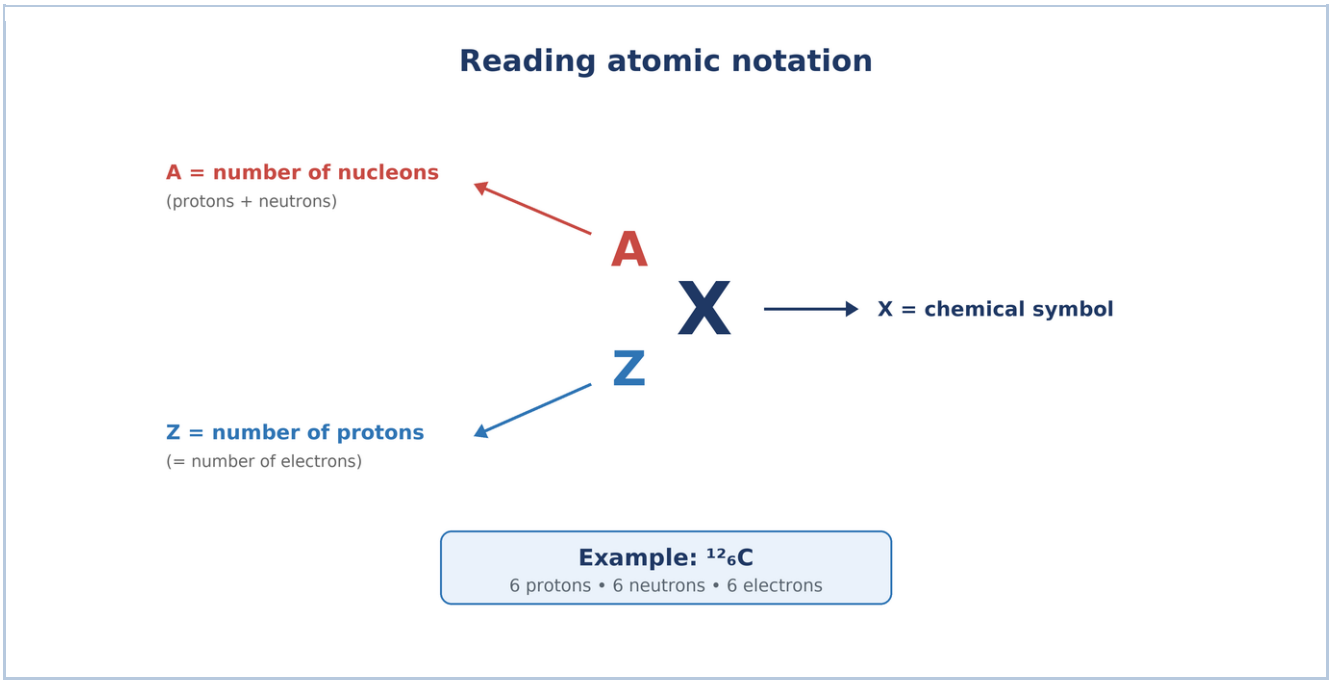
Example: For $^{12}_{6}C$ the atom is made up of:

6 protons because Z = 6

6 neutrons because A = 12 ➞ 12 nucleons − 6 protons = 6 neutrons

6 electrons because an atom is neutral, so there are as many electrons (charged −) as protons (charged +) ➞ 6 (+ charges) + 6 (− charges) =

Building atoms:



The periodic table

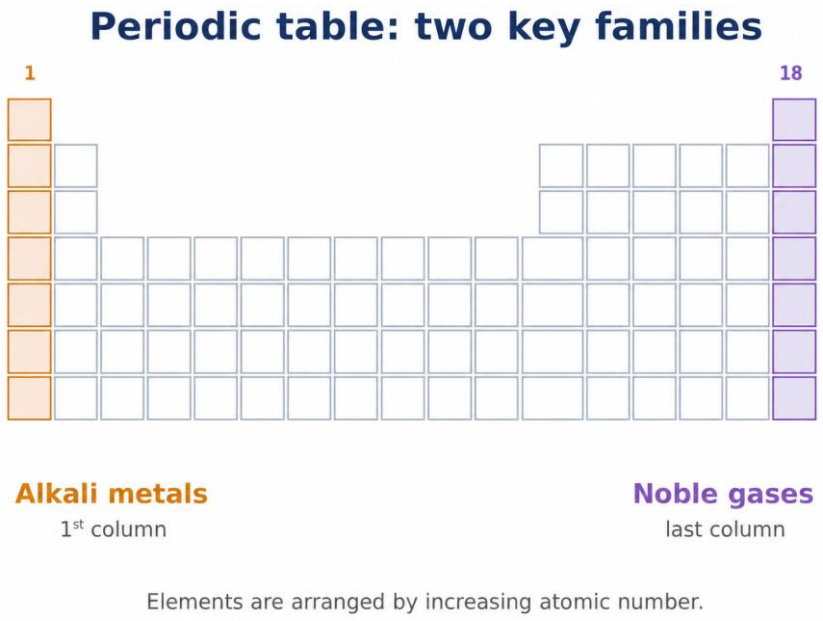
The periodic table is credited to Dmitri Mendeleev, who proposed an ordering of the elements based on the recurrence of their chemical properties. Some atoms have similar properties and are therefore grouped together.

So certain columns or blocks correspond to families of elements, all with similar chemical properties.

Example:

the noble gases in the last column are all very unreactive and generally gaseous.

the *alkali metals* in the first column, which tend to lose a single electron and are very reactive (especially with water). The atoms are ordered by increasing atomic number.



Key points — revision questions

- What does the nucleus of an atom contain?
- What are the electric charges of the particles in the nucleus?
- What do X, Z and A mean in atomic notation?
- Using the example of silver, $^{107}_{47}Ag$, what can be read from the atomic notation?

LEVEL 4

Bohr's model

Bohr proposed that electrons are arranged in shells around the nucleus:

Shell 1: up to 2 electrons

Shell 2: up to 8 electrons

Shell 3: up to 8 electrons (or 18 electrons for larger atoms)

Electrons fill the shells closest to the nucleus first (from 1 towards 3).

Stable or reactive?

An atom is stable when its outer shell is full. A stable atom tends to react less; otherwise it seeks to react in order to become stable:

it will form bonds with other atoms and make molecules.

it will gain or lose electrons to become an ion.

Examples:

Carbon (Z=6): $(1)^2(2)^4$ → unstable (mainly forms molecules)

Neon (Z=10): $(1)^2(2)^8$ → stable because the outer shell is complete.

Electron subshells

Each shell breaks down into subshells among which the electrons are spread.

There are 4 types of subshell:

s: the simplest, holding 2 electrons at most.

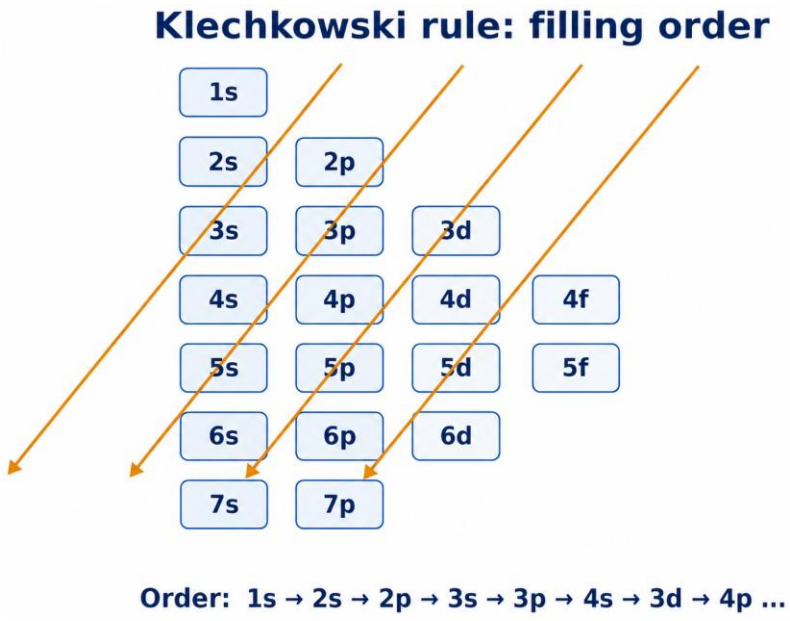
p: holding 6 electrons at most

d: holding 10 electrons at most

f: holding 14 electrons at most.

Klechkowski's rule

To fill the subshells in the right order, we use Klechkowski's rule



Examples:

Carbon (Z=6): $1s^2\ 2s^2\ 2p^2$

Neon (Z=10): $1s^2\ 2s^2\ 2p^6$

Key points — revision questions

- How are the electrons arranged around the nucleus?
- What determines the stability of an atom?