

Shells, groups and the periodic table

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: Electrons fill shells from the nucleus outwards, holding 2, 8 and 8 in the first three shells of the first 20 elements. The number of outer electrons gives the group, and the number of shells gives the period. Mendeleev ordered the elements by mass and left gaps, and Moseley fixed the order by atomic number.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-1, HS-PS1-2

How are electrons arranged in shells?

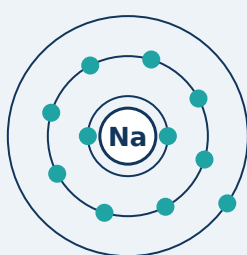
Electrons sit in **shells** (also called energy levels) around the nucleus. Each shell can hold only a limited number of electrons, and the lowest shell fills first.

Definition

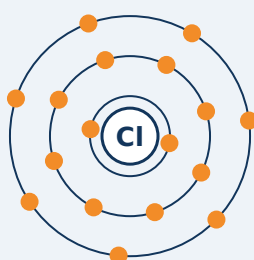
The **electron arrangement** of an atom lists the number of electrons in each shell, starting from the one nearest the nucleus, for example 2,8,5.

Key rule

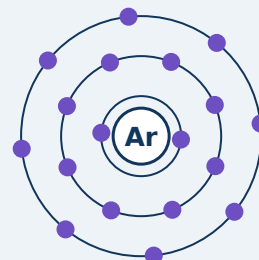
For the first 20 elements: shell 1 holds up to **2** electrons, shell 2 holds up to **8**, shell 3 holds up to **8**. Fill each shell before starting the next.



sodium 2,8,1



chlorine 2,8,7



argon 2,8,8

Fill the lowest shell first: 2, then 8, then 8 (first 20 elements)

Three period 3 atoms: sodium (2,8,1), chlorine (2,8,7) and argon (2,8,8).

The third period shows the pattern clearly. Each step to the right adds one proton and one electron.

Element	Atomic number	Electron arrangement	Outer electrons
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Element	Atomic number	Electron arrangement	Outer electrons
Sodium	11	2,8,1	1
Magnesium	12	2,8,2	2
Aluminium	13	2,8,3	3
Silicon	14	2,8,4	4
Phosphorus	15	2,8,5	5
Sulfur	16	2,8,6	6
Chlorine	17	2,8,7	7
Argon	18	2,8,8	8

Worked example 1

Write the electron arrangement of phosphorus (atomic number 15). A neutral atom has 15 electrons. Shell 1 takes 2, leaving 13. Shell 2 takes 8, leaving 5. Shell 3 takes the last 5.
Answer: **2,8,5**.

How does electron arrangement explain the periodic table?

The periodic table lists elements in order of atomic number. Rows are **periods** and columns are **groups**. The arrangement of electrons tells you exactly where an element belongs.

Key rule

The **group number** equals the number of electrons in the outer shell. The **period number** equals the number of occupied shells. Noble gases (Group 0) have a full outer shell.

Group	1	2		3	4	5	6	7	0
Period									
1	H								He
2	Li	Be		B	C	N	O	F	Ne
3	Na	Mg		Al	Si	P	S	Cl	Ar
4	K	Ca	transition metals	Ga	Ge	As	Se	Br	Kr

metal
 metalloid
 non-metal

Periods run across, groups run down. Metals sit on the left, non-metals on the right.

Worked example 2

An atom has the arrangement 2,8,8,2. It has $2 + 8 + 8 + 2 = 20$ electrons, so its atomic number is 20 (calcium). It has 4 shells, so it is in period 4. It has 2 outer electrons, so it is

in Group 2. Answer: **calcium, Group 2, period 4.**

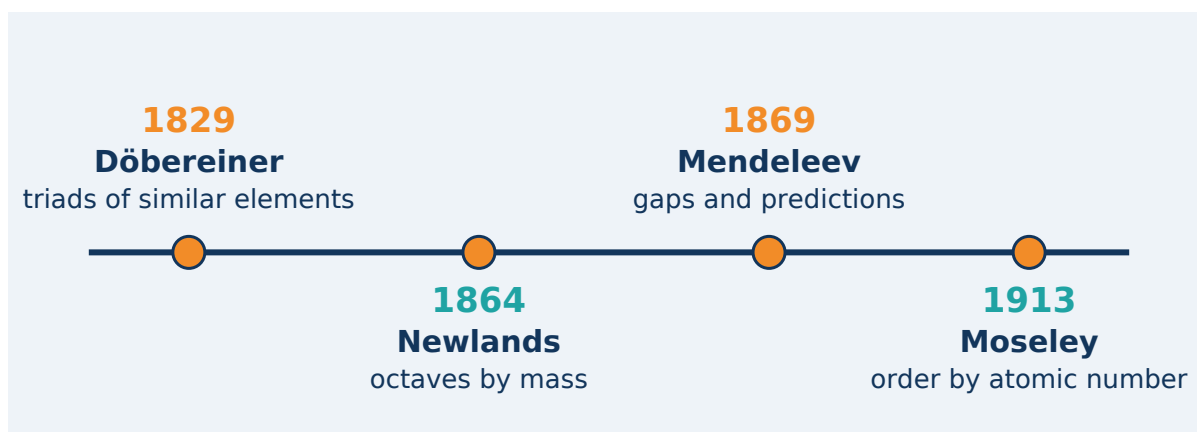
Common mistake

Do not mix up periods and groups. Sodium (2,8,1) is in Group 1 because of its 1 outer electron, but it is in period 3 because it has 3 shells. Helium has only 2 electrons, yet it is in Group 0 because its single shell is full.

Elements in one group have the same number of outer electrons, so they react in similar ways. Lithium, sodium and potassium each have one outer electron and all are soft, reactive metals. Metals are on the left and in the middle and tend to lose outer electrons. Non-metals are on the right and tend to gain or share them.

Who developed the periodic table?

Chemists first tried to organise the elements by their relative atomic mass. Johann Döbereiner noticed triads of similar elements. John Newlands saw that every eighth element was similar, but his pattern failed beyond calcium. In 1869 Dmitri Mendeleev made the most useful table. He placed elements in order of mass, started a new row when properties repeated, and **left gaps** for elements not yet found.



How ideas for sorting the elements developed.

Mendeleev predicted the properties of a missing element below silicon, which he called eka-silicon. Germanium, discovered in 1886, matched his predictions closely.

Property	Mendeleev's prediction	Germanium (measured)
Relative atomic mass	72	72.6
Density	5.5 g/cm ³	5.32 g/cm ³
Formula of oxide	XO ₂	GeO ₂
Formula of chloride	XCl ₄	GeCl ₄

Mendeleev also swapped a few elements, such as tellurium and iodine, so that elements with similar properties shared a column. Henry Moseley later showed in 1913 that the true order is by **atomic number**, which explained why those swaps were right.

Lina's tip

Read the arrangement from the right: the last number is the group number (for Groups 1 to 7) and the count of numbers is the period. For 2,8,6 the last number is 6 and there are 3 numbers, so Group 6, period 3.

Key points to remember

- Shells hold 2, 8, 8 electrons (first 20 elements); fill the lowest shell first.
- Group number = outer electrons; period number = number of shells; Group 0 has a full outer shell.
- Elements in the same group have the same outer electron number and react in similar ways.
- Mendeleev (1869) left gaps and predicted germanium; Moseley (1913) ordered by atomic number.
- Metals are on the left and in the centre and lose electrons; non-metals are on the right.

Shells, groups and the periodic table: frequently asked questions

How do you write an electron arrangement?

Find the number of electrons, which equals the atomic number of a neutral atom. Put 2 in the first shell, then 8 in the second, then up to 8 in the third, and so on. Write the numbers in order, separated by commas, such as 2,8,3.

How do you find the group and period from the electron arrangement?

The last number is the number of outer electrons, which gives the group. The number of shells, meaning how many numbers you wrote, gives the period. The arrangement 2,8,7 means Group 7 and period 3.

Why are noble gases unreactive?

A full outer shell is a very stable arrangement. Helium has 2 outer electrons and the other noble gases have 8. Their atoms have no tendency to lose, gain or share electrons.

Why did Mendeleev leave gaps in his table?

He believed that elements with similar properties should share a column. Where no known element fitted, he left a space and predicted the missing element. The properties of germanium matched his predictions, which convinced chemists.

What did Moseley change about the table?

Moseley showed that the elements should be ordered by atomic number, the number of protons, rather than by relative atomic mass. This explained cases like tellurium and iodine, where mass order gives the wrong column.