

The Periodic Table

How is the periodic table organized, and what does an element's position tell you?

●○○ Beginner

Atomic Structure & Periodicity

Last reviewed 5 October 2026

Before you start: it helps to understand [Inside the Atom: Protons, Neutrons and Electrons](#).

What is it?

The **periodic table** arranges all the known elements (118 of them) in order of increasing **atomic number** (number of protons), in rows and columns chosen so that elements with **similar properties line up in the same column**.

- A **period** is a horizontal row. There are 7 periods. The period number equals the number of the outermost occupied electron shell.
- A **group** is a vertical column, numbered 1 to 18. Elements in a group have the **same number of outer (valence) electrons**, so they react in similar ways.

Some groups have family names:

Group	Family	Typical behaviour
1	Alkali metals (Li, Na, K, ...)	Soft, very reactive metals; form 1+ ions; react with water to give hydrogen and an alkaline solution
2	Alkaline earth metals (Be, Mg, Ca, ...)	Reactive metals; form 2+ ions
3–12	Transition metals (Fe, Cu, Zn, ...)	Hard, dense metals; often coloured compounds; several possible ion charges
17	Halogens (F, Cl, Br, I)	Reactive non-metals; form 1– ions; exist as diatomic molecules (Cl ₂)
18	Noble gases (He, Ne, Ar, ...)	Very unreactive gases, with full outer shells

The two rows usually printed below the table are the **lanthanides** and **actinides**.

KEY IDEA

The table is **periodic** because properties repeat at regular intervals of atomic number. Elements in the same group behave similarly because they have the **same outer electron arrangement**. Position in the table predicts properties.

Why does it matter?

- **One chart, a huge amount of information.** From an element's position you can predict whether it is a metal, how many valence electrons it has, which ion it forms and roughly how reactive it is.
- **Writing formulas.** Group number gives the usual ion charge, which you need to name and write compounds.
- **It predicted new elements.** Gaps in Mendeleev's table were filled by elements discovered later, with the properties he forecast.

How does it work?

1. Metals, non-metals and metalloids

A staircase line from boron to astatine separates them:

- **Metals** (left and centre, about three-quarters of all elements): shiny, conduct heat and electricity, malleable, tend to **lose** electrons to form **positive** ions.
- **Non-metals** (top right, plus hydrogen): dull, poor conductors, brittle when solid, tend to **gain** or **share** electrons.
- **Metalloids** (along the staircase: B, Si, Ge, As, Sb, Te): in-between properties. Silicon and germanium are **semiconductors**, the basis of computer chips.

2. Valence electrons and ions

For the main groups:

- Groups 1 and 2: 1 and 2 valence electrons; they lose them to form **1+** and **2+** ions.
- Groups 13–18: the valence electrons are the group number minus 10 (3 to 8). Group 13 metals form **3+** ions; groups 15, 16 and 17 gain electrons to form **3–**, **2–** and **1–** ions.

Each ion then has the same electron arrangement as the nearest noble gas.

3. Blocks

The table is divided into **blocks** according to the subshell being filled by the outermost electrons: the **s-block** (groups 1–2, and helium), **p-block** (groups 13–18), **d-block** (groups 3–12) and **f-block** (lanthanides and actinides). The block widths, 2, 6, 10 and 14 elements, are the numbers of electrons each subshell can hold.

4. Mendeleev's table

In 1869 the Russian chemist Dmitri Mendeleev arranged the 63 elements then known by atomic mass and by their properties. He left **gaps** for undiscovered elements and predicted their properties. His “eka-silicon”, below silicon, was discovered in 1886 and named **germanium**. Later, the order was found to depend on **atomic number**, not mass, which fixed a few pairs that looked out of order (such as tellurium and iodine).

∞ THINK OF IT LIKE THIS

The periodic table works like a calendar. Days are in order, but they are arranged in weeks so that all the Mondays line up in one column. Elements are in order of atomic number, but arranged in periods so that elements with similar “personalities” line up in one group.

🔍 MORE PRECISELY

Hydrogen is placed in group 1 because it has one electron, but it is a non-metal and in some ways resembles the halogens too. Helium has 2 valence electrons and belongs to the s-block, but it is placed with the noble gases because its shell is full. Which elements to call metalloids varies slightly between sources (polonium and astatine are sometimes included). The heaviest elements (above about 100) are made artificially, a few atoms at a time.

Visualise it

The periodic table by block

Rows are periods (1–7); columns are groups (1–18).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

■ s-block ■ d-block ■ p-block ■ f-block

The four blocks of the periodic table. Each element's block tells you which subshell its outermost electrons are filling.

Worked example

WORKED EXAMPLE: Locating an element

Question: Identify the element in period 3, group 17, and describe it.

- Step 1** Period 3, group 17 is **chlorine** (Cl).
- Step 2** Group 17: a **halogen**, a reactive **non-metal**, with **7** valence electrons.
- Step 3** It gains one electron to form the chloride ion, Cl^- , which has the same arrangement as argon.

WORKED EXAMPLE: Predicting ions and a formula

Question: Predict the ions formed by magnesium and nitrogen, and the formula of magnesium nitride.

- Step 1** Magnesium is in group 2: it loses 2 electrons, forming Mg^{2+} .
- Step 2** Nitrogen is in group 15: it has 5 valence electrons and gains 3, forming N^{3-} .
- Step 3** Charges must balance: $3 \times (+2) + 2 \times (-3) = 0$, so the formula is Mg_3N_2 .

WORKED EXAMPLE: Testing Mendeleev's prediction

Question: Mendeleev predicted that eka-silicon would have an atomic mass of 72 and a density of 5.5 g/cm^3 . Germanium has an atomic mass of 72.63 and a density of 5.32 g/cm^3 . Calculate the percent error of each prediction.

- Step 1** Atomic mass:

$$\frac{72 - 72.63}{72.63} \times 100\% \\ = -0.87\%$$

- Step 2** Density:

$$\frac{5.5 \text{ g/cm}^3 - 5.32 \text{ g/cm}^3}{5.32 \text{ g/cm}^3} \\ \times 100\% \\ = +3.4\%$$

- Step 3** Both predictions were within a few percent, made 15 years before the element was found.

 WORKED EXAMPLE: Classifying an unknown element

Question: Element X is a shiny grey solid, but it is brittle and conducts electricity only weakly. It is in group 14, period 3. What is it, and how is it classified?

Period 3, group 14 is **silicon**. Its mixed properties (shiny like a metal, brittle like a non-metal, a semiconductor) make it a **metalloid**.

Common mistake

 COMMON MISTAKE: Confusing periods and groups

Periods are rows (across); **groups** are columns (down). Elements in a **group** have similar properties; elements in a **period** change gradually from metals to non-metals.

 COMMON MISTAKE: Thinking the table is ordered by atomic mass

The modern table is ordered by **atomic number**. Argon (39.95) comes before potassium (39.10) even though it is heavier, because argon has 18 protons and potassium 19.

 COMMON MISTAKE: Counting group 13–18 valence electrons as the group number

With the 1–18 numbering, aluminium (group 13) has 3 valence electrons, not 13. Subtract 10 for groups 13–18.

 NOTATION NOTE

- Older tables number the main groups I–VIII (or 1A–8A). Group VII = group 17; group 0 or VIII = group 18.
- Hydrogen is usually shown at the top of group 1, but it is not an alkali metal.

Remember this

REMEMBER THIS

- Ordered by atomic number. Periods = rows (1–7); groups = columns (1–18).
- Same group = same number of valence electrons = similar properties.
- Group 1 alkali metals, group 2 alkaline earth metals, 3–12 transition metals, 17 halogens, 18 noble gases.
- Metals left, non-metals top right, metalloids along the staircase.
- Ions: groups 1, 2, 13 → 1+, 2+, 3+; groups 15, 16, 17 → 3–, 2–, 1–.
- Blocks: s (2 wide), p (6), d (10), f (14).

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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