

# Electron Configuration

How do you write electron configurations?

●●○ Intermediate

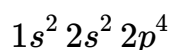
Atomic Structure & Periodicity

Last reviewed 3 October 2026

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

## What is it?

An **electron configuration** shows how an atom's electrons are arranged in **shells** and **subshells**. For example, oxygen (8 electrons) is:



Read it as: 2 electrons in the 1s subshell, 2 in 2s, and 4 in 2p.

- The **number** is the shell (energy level),  $n = 1, 2, 3...$
- The **letter** is the subshell type: **s**, **p**, **d** or **f**.
- The **superscript** is the number of electrons in that subshell.

### KEY IDEA

Electrons fill the lowest-energy subshells first. Each subshell holds a fixed maximum: **s** = 2, **p** = 6, **d** = 10, **f** = 14 electrons.

## Why does it matter?

- **It explains the periodic table.** Elements in the same group have similar outer (valence) configurations, which is why they behave alike.
- **It predicts chemistry.** The number of valence electrons determines how an atom bonds and what ions it forms.
- **It explains colour, magnetism and more.** Unpaired electrons and partly filled d subshells give many transition-metal compounds their colours and magnetic properties.

# How does it work?

## 1. Shells, subshells and orbitals

| Subshell | Orbitals | Maximum electrons |
|----------|----------|-------------------|
| s        | 1        | 2                 |
| p        | 3        | 6                 |
| d        | 5        | 10                |
| f        | 7        | 14                |

Each **orbital** holds at most **2 electrons** with opposite spins (the **Pauli exclusion principle**).

## 2. The filling order (Aufbau principle)

Subshells fill in order of increasing energy:

1s → 2s → 2p → 3s → 3p → **4s** → **3d** → 4p → 5s → 4d → 5p → 6s → 4f → 5d → 6p → 7s → 5f → 6d → 7p

Notice that **4s fills before 3d**. The diagonal diagram below is an easy way to remember the order.

## 3. Hund's rule

Within a subshell, electrons occupy **separate orbitals with parallel spins** before any orbital gets a second electron. For nitrogen's three 2p electrons:  $\uparrow \uparrow \uparrow$ , not  $\uparrow \downarrow \uparrow$  or  $\uparrow \uparrow \downarrow$ .

## 4. Noble-gas shorthand

Replace the inner (core) electrons with the previous noble gas in square brackets:

- Sodium:  $1s^2 2s^2 2p^6 3s^1 = [\text{Ne}] 3s^1$
- Iron:  $[\text{Ar}] 3d^6 4s^2$  (also written  $[\text{Ar}] 4s^2 3d^6$ )

## 5. Ions

- Anions:** add electrons.  $\text{Cl}^-$ :  $[\text{Ne}] 3s^2 3p^6 = [\text{Ar}]$ .
- Main-group cations:** remove electrons from the outermost subshell.  $\text{Na}^+$ :  $[\text{Ne}]$ .
- Transition-metal cations:** remove **4s electrons first**, then 3d.  $\text{Fe}^{2+}$ :  $[\text{Ar}] 3d^6$ ;  $\text{Fe}^{3+}$ :  $[\text{Ar}] 3d^5$ .

### ∞ THINK OF IT LIKE THIS

Think of a hotel filling rooms from the ground floor up. Guests (electrons) take the cheapest rooms (lowest energy) first. Hund's rule is like passengers on a bus: people take empty double seats on their own before anyone sits next to a stranger.

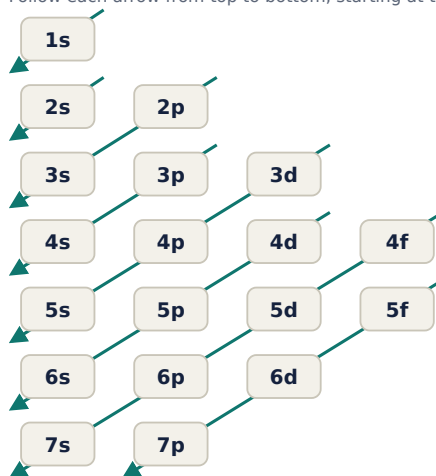
### 🔍 MORE PRECISELY

A few elements break the simple filling order because half-filled and completely filled d subshells are especially stable: chromium is **[Ar] 3d<sup>5</sup> 4s<sup>1</sup>** (not 3d<sup>4</sup> 4s<sup>2</sup>) and copper is **[Ar] 3d<sup>10</sup> 4s<sup>1</sup>** (not 3d<sup>9</sup> 4s<sup>2</sup>). Also, once the 3d subshell contains electrons, its energy drops below 4s. That's why transition metals lose their 4s electrons first when they form ions.

## Visualise it

### Order of filling subshells

Follow each arrow from top to bottom, starting at the top.



1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p → 5s → 4d →  
5p → 6s → 4f → 5d → 6p → 7s → 5f → 6d → 7p

Follow the diagonal arrows to get the filling order.

## Worked example

### ✂️ WORKED EXAMPLE: Writing a configuration

**Question:** Write the full and noble-gas configurations of sulfur ( $Z = 16$ ).

**Step 1** 16 electrons, filled in order: 1s<sup>2</sup> (2), 2s<sup>2</sup> (4), 2p<sup>6</sup> (10), 3s<sup>2</sup> (12), 3p<sup>4</sup> (16)

**Step 2** Full: 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>4</sup>

**Step 3** Noble-gas form: **[Ne] 3s<sup>2</sup> 3p<sup>4</sup>**: 6 valence electrons, two of them unpaired (Hund's rule).

 **WORKED EXAMPLE:** A transition-metal ion

**Question:** Write the configuration of  $\text{Fe}^{3+}$  (Fe:  $Z = 26$ ).

**Step 1** Fe atom:  $[\text{Ar}] 3d^6 4s^2$

**Step 2** Remove 3 electrons, **4s first**: remove both 4s electrons, then one 3d electron.

**Step 3**  $\text{Fe}^{3+}$ :  $[\text{Ar}] 3d^5$  (five unpaired electrons, one in each 3d orbital)

## Common mistake

 **COMMON MISTAKE:** Filling 3d before 4s

Potassium is  $[\text{Ar}] 4s^1$ , not  $[\text{Ar}] 3d^1$ . The 4s subshell fills before 3d.

 **COMMON MISTAKE:** Removing 3d electrons first from transition metals

When transition metals form ions, the **4s** electrons are removed first.  $\text{Fe}^{2+}$  is  $[\text{Ar}] 3d^6$ , not  $[\text{Ar}] 3d^4 4s^2$ .

 **COMMON MISTAKE:** Pairing electrons too early

Hund's rule: put one electron in each orbital of a subshell before pairing. Oxygen's  $2p^4$  is  $[\uparrow\downarrow] [\uparrow] [\uparrow]$ , with two unpaired electrons.

 **NOTATION NOTE**

- Superscripts are sometimes written on the line, e.g.  $1s2\ 2s2\ 2p4$ , when superscripts aren't available.
- The order of writing 3d and 4s varies between textbooks ( $[\text{Ar}] 3d^6 4s^2$  or  $[\text{Ar}] 4s^2 3d^6$ ). Both are accepted.
- "Aufbau" is German for "building up".

## Remember this

 **REMEMBER THIS**

- Subshell capacities: s 2, p 6, d 10, f 14; each orbital holds 2 electrons.
- Fill in order (4s before 3d); Hund's rule: spread out before pairing.
- Noble-gas shorthand: [previous noble gas] + outer electrons.
- Transition-metal ions lose 4s electrons first. Exceptions: Cr and Cu.

# 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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