

The periodic table: classification of elements

Structure 3.1 · SL

How did Mendeleev predict germanium?

The table works because properties repeat in a regular way.

- In 1869 he left gaps where the pattern said an element should be.
- Germanium, found in 1886, matched his "eka-silicon".
- This unit: organization → trends → groups 1 and 17 → oxides → oxidation states.

Periods, groups and blocks

Feature	Tells you	Example: Cl
period	outer energy level	3
group	outer electrons	17 (7 outer)
block	sublevel being filled	p

Two ideas explain every trend

Across a period

Nuclear charge rises; same energy level.

Shielding hardly changes, so a stronger pull.

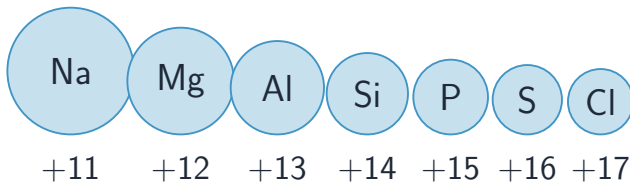
Down a group

One more full inner level each time.

Further away and more shielded, so a weaker pull.

Atomic radius

atomic radius decreases as nuclear charge increases



A stronger pull draws the same outer level closer.

Ionic radius

Atom against ion

Na 186 pm, Na⁺ 102 pm.

Cl 102 pm, Cl⁻ 181 pm.

Neon configuration

N³⁻ > O²⁻ > F⁻ > Na⁺ > Mg²⁺ > Al³⁺

Same 10 electrons, rising **nuclear charge**.

Three trends that move together

Property	Across a period	Down a group
first ionization energy	increases	decreases
electron affinity	more negative	less negative
electronegativity	increases	decreases

Check: atomic radius

Your turn

Which ion is the largest?

- A. Mg^{2+}
- B. Na^{+}
- C. F^{-}
- D. O^{2-}

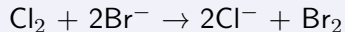
Opposite trends in groups 1 and 17

Alkali metals



More reactive down the group.

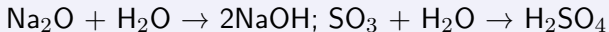
Halogens



Less reactive down the group.

Oxides across period 3

Na_2O	MgO	Al_2O_3	P_4O_{10}	SO_3
basic		amphoteric	acidic	
$\text{pH} \approx 14$		$\text{pH} \approx 7$	$\text{pH} \approx 0$	
metal oxides (left) are basic; non-metal oxides (right) are acidic				



Acid deposition and ocean acidification

Non-metal oxides from burning fuels make rain and oceans more **acidic**.

- SO_2 and nitrogen oxides form sulfuric and nitric acids in rain.
- CO_2 forms carbonic acid in seawater.
- Lower pH harms limestone, forests, lakes, corals and shellfish.

Assigning oxidation states

1 **Oxygens.** MnO_4^- : $4(-2) = -8$

2 **Total.** $\text{Mn} + (-8) = -1$

3 **Solve.** Mn is +7.

Decision

Name with Roman numerals when a state can vary, as in iron(III) chloride.

Exam tips

Always state what happens to the attraction for the outer electrons.

- Explain trends with **nuclear charge**, **shielding** and distance.
- Isoelectronic ions differ only in nuclear charge.
- Oxidation states take the sign first, +3.

Check yourself

Try these

Order Mg^{2+} , Na^+ , F^- and O^{2-} by radius and explain.

Explain why potassium reacts more vigorously with water than sodium.

Find the oxidation state of Cr in $\text{Cr}_2\text{O}_7^{2-}$.