The periodic table: classification of elements

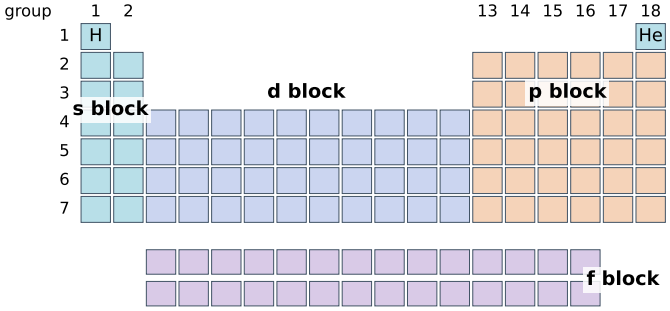
Structure 3.1 · SL

One table, useful predictions

> A trend is a pattern to explain, with conditions and exceptions.

- Atomic number organizes the modern table.
- Configuration helps explain recurring properties.

Locate periods, groups and blocks



He: group 18, configuration $1s^2$; detached f rows are schematic

Main-group patterns need the helium and hydrogen exceptions.

From position to configuration

1. **Position.** Br: period 4, group 17.
2. **Configuration.** [Ar] $3d^{10}4s^{2}4p^{5}$.
3. **Check.** $18 + 10 + 2 + 5 = 35$ electrons.

Decision

Cr and Cu are familiar exceptions to the simple $3d^{n}4s^{2}$ starting pattern.

Explain attraction before naming a trend

Across a main period

Nuclear charge rises; added electrons occupy the same main level.

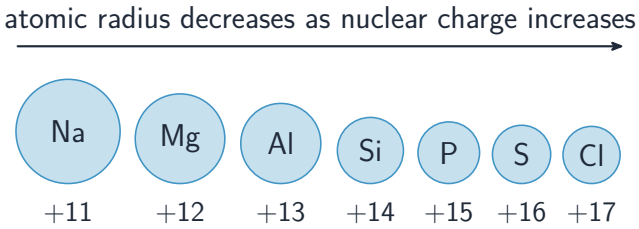
Similar inner **shielding** gives greater attraction overall.

Down a main group

Outer electrons occupy a higher principal level.

Distance and shielding usually outweigh the larger nuclear charge.

Compare atomic radii consistently



Across period 3, increasing nuclear attraction generally contracts the atoms.

Order an isoelectronic set

1. **Electron count.** Mg^{2+}, Na^{+}, F^{-} and O^{2-} all have 10 electrons.
2. **Nuclei.** Their charges are $+12$, $+11$, $+9$ and $+8$.
3. **Increasing radius.** $Mg^{2+} < Na^{+} < F^{-} < O^{2-}$.

Decision

Greater **nuclear charge** contracts the same electron count.

Three different electron questions

Quantity	**What changes?**
first IE	gaseous atom $\rightarrow$ gaseous $1+$ ion $+$ electron
electron-gain enthalpy	gaseous atom $+$ electron $\rightarrow$ gaseous $1-$ ion
electronegativity	attraction for shared density in a bond

An affinity exception: F and Cl

1. **Electron-gain enthalpies.** F -328; Cl -349 kJ/mol.
2. **Compare.** Cl releases 21 kJ/mol more energy.
3. **Explain.** F's compact 2p region increases incoming-electron repulsion.

Decision

A monotonic down-group rule misses the F/Cl exception.

Opposite group trends

Group 1: oxidation

$2Na + 2H_2O \rightarrow 2NaOH + H_2$.

Reactivity generally rises down the group as electron loss becomes easier.

Group 17: reduction

$X_2 + 2e^- \rightarrow 2X^-$.

Oxidizing ability generally falls down the group; bonds and solvation also matter.

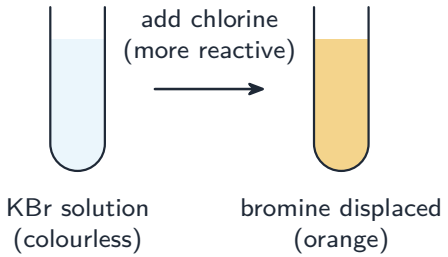
Predict a halide displacement

1. **Equation.** $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$.
2. **Observation.** A brown iodine-containing solution forms.
3. **Reverse?** I_2 does not ordinarily oxidize Cl^- in this displacement test.

Decision

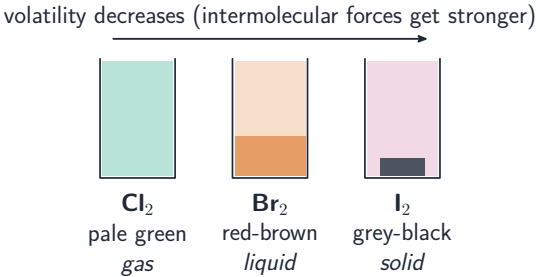
Chlorine is the stronger oxidizing agent under these conditions.

A halogen displacement



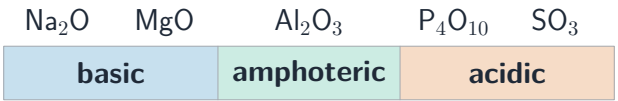
A more reactive **halogen** displaces a less reactive one

The halogens at room temperature



Larger molecules, stronger London forces

Oxide character is not a fixed pH



SiO_2: acidic, but unreactive with water

Solubility, amount and water volume matter for actual pH.

Write oxide–water equations

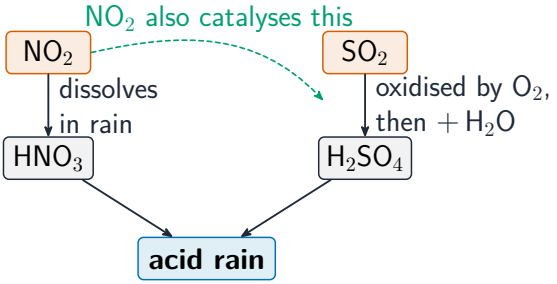
Oxide	Simplified reaction
Na_2O	$Na_2O + H_2O \rightarrow 2NaOH$
CaO	$CaO + H_2O \rightarrow Ca(OH)_2$
CO_2	$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$
SO_3	$SO_3 + H_2O \rightarrow H_2SO_4$

Separate acid deposition and ocean acidification

Acidification is a fall in pH; seawater can remain alkaline.

- Oxidation of SO_2 and nitrogen oxides can form strong acids in rain.
- Dissolved CO_2 increases H^+ and reduces available carbonate.

How acid rain forms



Non-metal oxides are **acidic**

Assign oxidation states by a sum

1. **Species.** $Cr_2O_7^{2-}$ has seven O atoms at -2.
2. **Sum.** $2\mathrm{Cr} - 14 = -2$.
3. **Solve.** $\mathrm{Cr} = +6$; use Roman numerals where needed in naming.

Decision

An uncombined element is 0; inequivalent atoms can give an average state.

Check the usual exceptions

Species	**Sum**	**Result**
NaH	$+1 + \mathrm{H} = 0$	H -1
$\mathrm{H_2O_2}$	$2(+1) + 2\mathrm{O} = 0$	O -1
$\mathrm{OF_2}$	$\mathrm{O} + 2(-1) = 0$	O $+2$

Assigning an oxidation number

known	unknown	known
K	Mn	O_4
$+1$	$+7$	$4 \times (-2)$

they sum to 0: $(+1) + \text{Mn} + (-8) = 0$, so $\text{Mn} = +7$

So Mn is $+7$

Exam tips

> Support the claim with the particles, energy change and conditions involved.

- Use the actual configuration and a consistent sign convention.
- Balance equations; do not invent concentrations or exact pH values.

Check yourself

Apply the explanation

Explain the He group/block exception and order the ten-electron ions by radius.

Balance a halogen displacement and distinguish acidification from pH below 7.

Find H in NaH and O in H_2O_2 and OF_2.