

Alkali metals, halogens and noble gases

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

Quick answer: Group 1 metals have one outer electron and become more reactive down the group, reacting with water to make hydrogen and an alkaline hydroxide. Group 7 halogens have seven outer electrons and become less reactive down the group, so a halogen displaces a weaker one. Group 0 gases have full shells and are unreactive.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C1, IGCSE 9

What are the properties of the Group 1 alkali metals?

Group 1 contains lithium, sodium, potassium, rubidium and caesium. Their atoms all have **one outer electron**. The metals are soft enough to cut with a knife, have low melting points and low densities, and lithium, sodium and potassium float on water. Fresh cuts are shiny but tarnish within seconds in air, so the metals are stored under oil.

Definition

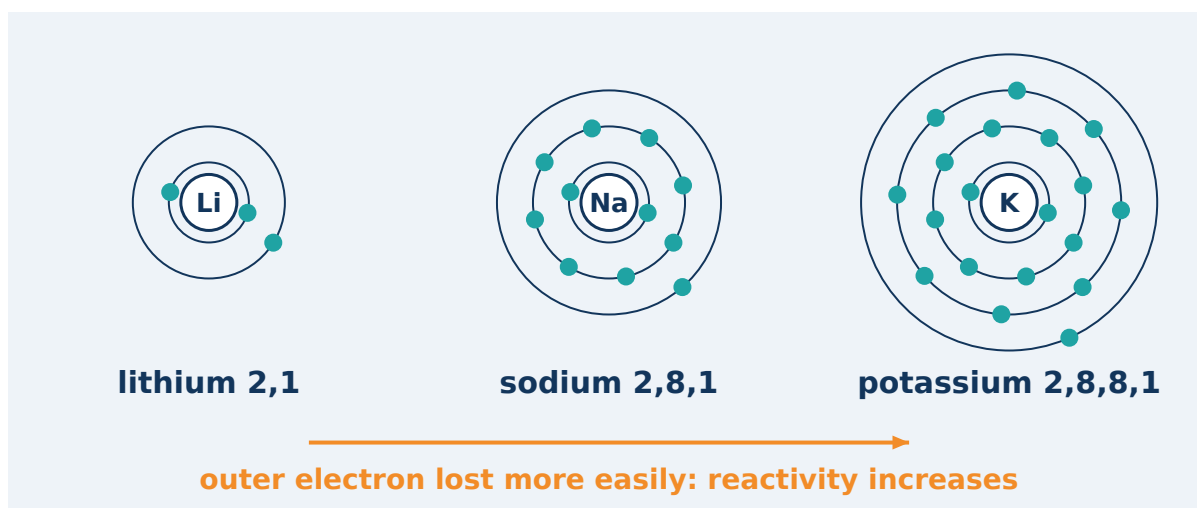
The **alkali metals** are the Group 1 elements. They react with water to give a hydrogen gas and an alkaline metal hydroxide solution.

Each alkali metal reacts with water to form the metal hydroxide and hydrogen. The hydroxide solution is alkaline, with a pH above 7, and the hydrogen gives a squeaky pop with a lit splint.

Metal	Melting point	Reaction with water
Lithium	181 °C	Fizzes steadily and moves slowly
Sodium	98 °C	Melts into a ball and fizzes quickly
Potassium	63 °C	Melts, darts around and burns with a lilac flame

Worked example 1

Write the balanced equation for potassium and water. Potassium forms potassium hydroxide, KOH, and hydrogen, H₂. Start with $K + H_2O \rightarrow KOH + H_2$. Hydrogen has two atoms on the right, so use 2K and 2H₂O, giving **$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$** . Check: 2 K, 4 H and 2 O on each side.

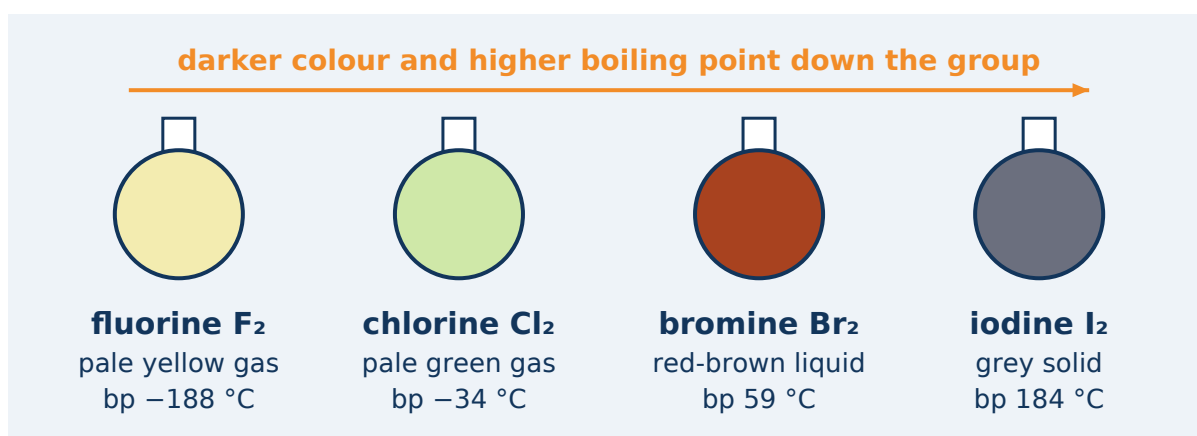


Going down Group 1 the single outer electron sits in a bigger shell, further from the nucleus.

Reactivity **increases** down the group. The outer electron is further from the nucleus and is shielded by more full shells, so it is held less strongly and is lost more easily.

What are the properties of the Group 7 halogens?

The halogens have **seven outer electrons**. They exist as molecules of two atoms (F_2 , Cl_2 , Br_2 , I_2) and are poisonous non-metals. Their colour gets darker and their melting and boiling points rise down the group.



Colour and state of the halogens at room temperature, with boiling points.

Key rule

Reactivity **decreases** down Group 7. A halogen atom reacts by gaining one electron. In a small atom the incoming electron is close to the nucleus and is strongly attracted. In a larger atom it is further away and more shielded.

This trend lets a more reactive halogen **displace** a less reactive one from a solution of its salt.

		
$\text{Cl}_2(\text{aq}) + \text{KBr}(\text{aq})$ orange solution bromine made	$\text{Br}_2(\text{aq}) + \text{KI}(\text{aq})$ brown solution iodine made	$\text{Br}_2(\text{aq}) + \text{KCl}(\text{aq})$ no change orange-yellow

Displacement tests: a more reactive halogen replaces a less reactive one in solution.

Worked example 2

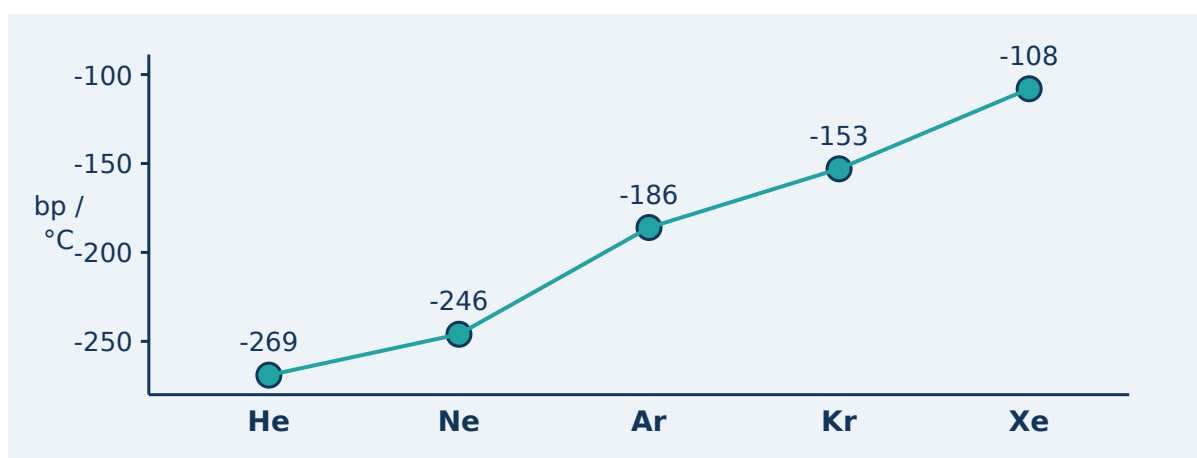
Predict what happens when bromine water is added to sodium iodide solution. Bromine is above iodine in Group 7, so it is more reactive and displaces iodine. The solution turns brown. Equation: $\text{Br}_2 + 2\text{NaI} \rightarrow 2\text{NaBr} + \text{I}_2$. Mixing bromine water with sodium chloride gives no reaction, because bromine is less reactive than chlorine.

Common mistake

The two groups behave in opposite ways. Group 1 gets *more* reactive down the group, but Group 7 gets *less* reactive down the group. Metals lose electrons and non-metals gain them, so the distance from the nucleus has opposite effects.

Why are the noble gases so unreactive?

The noble gases in Group 0 (helium, neon, argon, krypton, xenon) have full outer shells, so they almost never form compounds. They exist as single atoms and their boiling points rise down the group.



Boiling points rise down Group 0.

Their unreactive nature makes them useful. Helium is less dense than air and does not burn, so it lifts balloons and airships safely. Neon glows red-orange in advertising signs. Argon fills filament lamps and protects metal during welding, because it will not react with the hot metal.

Lina's tip

Link the trend to the direction of electron movement. Metals *lose* an electron, so a far-away electron means more reactive. Halogens *gain* an electron, so a far-away gap means less reactive.

Key points to remember

- Group 1: soft metals with 1 outer electron; reactivity increases down; $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$.
- Group 7: diatomic non-metals with 7 outer electrons; reactivity decreases down the group.
- A more reactive halogen displaces a less reactive one: $\text{Cl}_2 + 2\text{KBr} \rightarrow 2\text{KCl} + \text{Br}_2$.
- Group 0 (noble gases): full outer shells, single atoms, unreactive; boiling points rise down the group.
- Uses: helium in airships, neon in signs, argon in filament lamps and welding.

Alkali metals, halogens and noble gases: frequently asked questions

Why does reactivity increase down Group 1?

Going down the group, the outer electron is in a shell further from the nucleus and is shielded by more inner shells. It is held less strongly, so the atom loses it more easily. This makes the metal more reactive.

Why does reactivity decrease down Group 7?

A halogen atom must gain one electron. Going down the group, the atoms are larger, so the incoming electron is further from the nucleus and more shielded. It is attracted less, so the halogen is less reactive.

What is a halogen displacement reaction?

It is a reaction in which a more reactive halogen takes the place of a less reactive halogen in a salt solution. Chlorine displaces bromine from potassium bromide, for example, and the solution turns orange. A less reactive halogen cannot displace a more reactive one.

What gas forms when an alkali metal reacts with water?

The gas is hydrogen. It burns with a squeaky pop when a lit splint is held at the mouth of a test tube. The solution left behind is alkaline because it contains the metal hydroxide.

Why are noble gases unreactive?

Their atoms have full outer shells of electrons, which is a very stable arrangement. They have no tendency to lose, gain or share electrons. This is why helium, neon and argon are used where a safe, unreactive gas is needed.