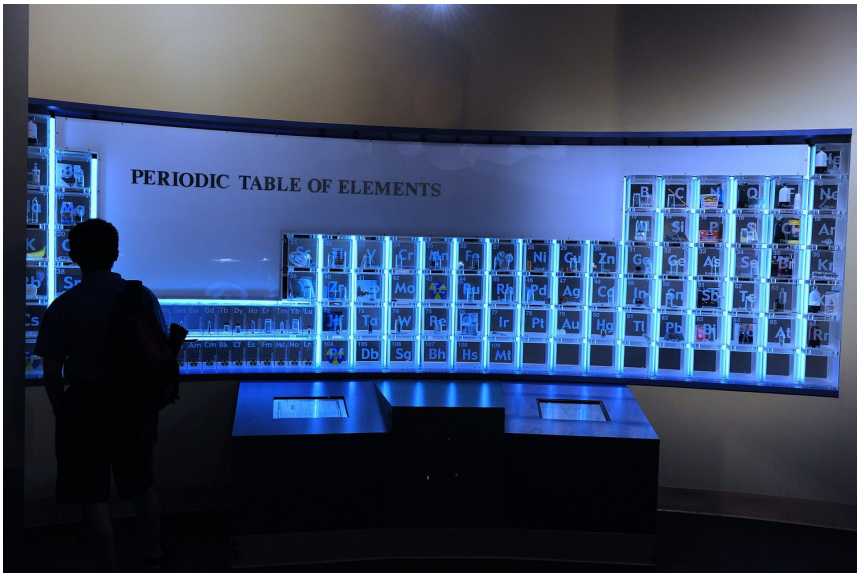
The Periodic Table

IGCSE Chemistry

Arrangement of the elements



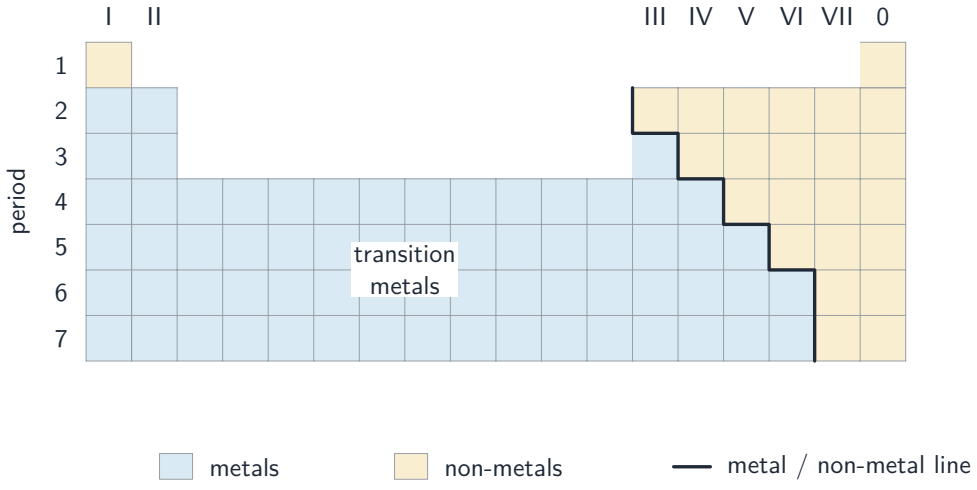
The periodic table arranges the elements in order of atomic number.

The **Periodic Table** 周期表 arranges all the **elements** 元素 in order of increasing **proton number** 质子数 (the **atomic number** 原子序数). The horizontal rows are called **periods** 周期 and the vertical columns are called **groups** 族.

A few key patterns:

- Across a period, the elements change from **metals** 金属 on the left to **non-metals** 非金属 on the right.
- The group number tells you the charge of the **ions** 离子 that the elements form. Group I forms $+1$ ions, Group II forms $+2$ ions, and Group VII forms -1 ions.
- Elements in the same group have similar chemical properties. This is because they have the same number of outer-shell **electrons** 电子 (the same outer **electronic configuration** 电子排布).

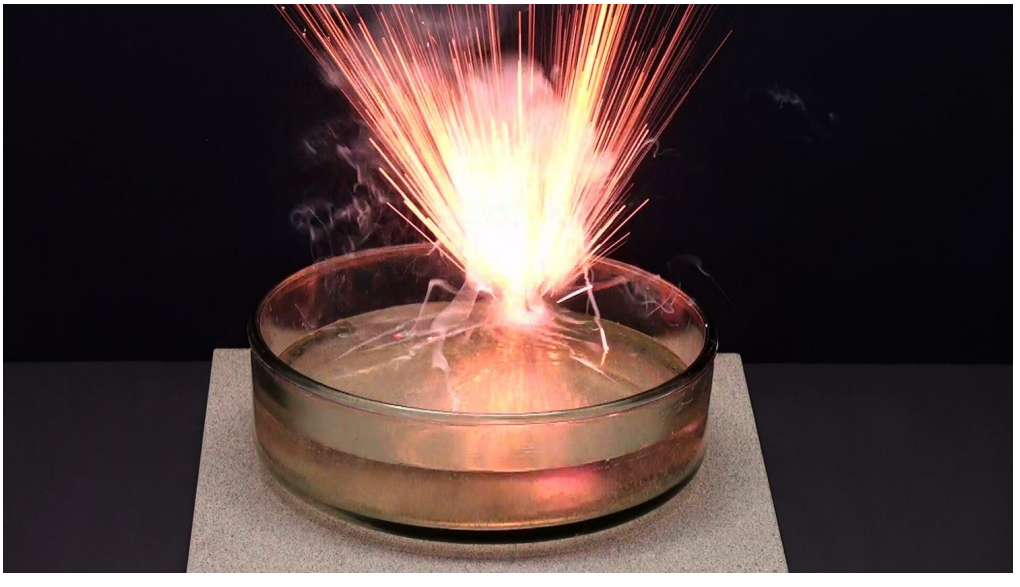
Because of these patterns, you can use an element's position to predict its properties.



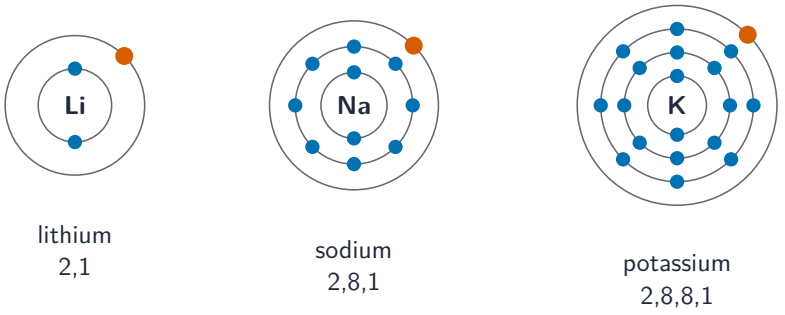
Groups are the columns and periods are the rows; metals lie to the left of the staircase, non-metals to the right

Group I — the alkali metals

Group I elements are the **alkali metals** 碱金属: **lithium** 锂, **sodium** 钠 and **potassium** 钾. They are **soft** 柔软 metals (you can cut them with a knife).



Potassium reacts violently with water, giving off hydrogen that burns with a lilac flame — reactivity increases down Group I



every Group I atom has **one** electron in its outer shell (shown in orange), so they react in similar ways

Every Group I atom has one electron in its outer shell, which is why they react in similar ways

Going down the group, there are clear **trends** 趋势:

Property	Trend going down the group
melting point 熔点	decreases
density 密度	increases
reactivity 活泼性	increases

You can use these trends to predict the properties of other Group I elements. For example, rubidium (below potassium) would be even more reactive and have an even lower melting point.

Reaction with water, and what you see

This is the reaction the exam asks about most. Every Group I metal reacts with water to give an **alkali** (the metal hydroxide) plus **hydrogen** - which is exactly why they are called the alkali metals:

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

"Describe what you see" is worth marks of its own, so learn the list for **sodium on water**:

- it **floats** - the metal is less dense than water.
- it **melts into a ball** - the reaction gives out heat, and the metal's melting point is low.
- it **moves about** on the surface - the hydrogen jetting off pushes it around.
- there is **effervescence** 泡腾 (fizzing) - the hydrogen gas escaping.
- it **gets smaller and disappears** as it is used up.

- the solution turns **alkaline**, so universal indicator goes **purple** (it is now NaOH).

The trend shows up in how violent this is: **lithium** fizzes steadily but does not melt; **sodium** melts into a ball and darts around; **potassium** is fast enough to ignite its own hydrogen, burning with a **lilac flame**. Two answers to avoid: "hydrogen is given off" is not an observation (you cannot see it - say **effervescence**), and the metal melts because the **reaction is exothermic**, not because "water is hot".

Group VII — the halogens

Group VII elements are the **halogens** 卤素: **chlorine** 氯气, **bromine** 溴 and **iodine** 碘. They are **diatomic** 双原子 non-metals (each molecule is made of two atoms, such as Cl_2).

Their appearance at room temperature and pressure:

Halogen	Appearance
chlorine	a pale yellow-green gas
bromine	a red-brown liquid
iodine	a grey-black solid

Going down the group, the density increases but the reactivity **decreases** (the opposite trend to Group I).

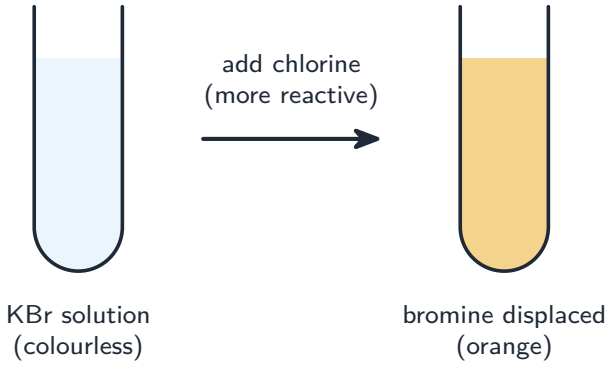
Group I gets more reactive down the group, while Group VII gets less reactive down — opposite trends

Displacement reactions

A more reactive halogen pushes out (displaces) a less reactive **halide** 卤化物 ion from its solution. This is a **displacement reaction** 置换反应.

For example, chlorine is more reactive than bromine, so chlorine displaces bromine from potassium bromide:

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$



Chlorine is more reactive, so it displaces bromine from the solution; the released bromine turns the colourless solution orange

Worked example. Aqueous chlorine is added to potassium iodide solution; then aqueous iodine is added to potassium bromide solution. What happens in each? Reactivity falls **down** Group VII: chlorine, then bromine, then iodine. (a) Chlorine is above iodine, so it is more reactive and displaces it: $Cl_2 + 2KI \rightarrow 2KCl + I_2$, and the solution turns red-brown as iodine is released. (b) Iodine is **below** bromine, so it is less reactive and cannot displace it - there is **no reaction** and no colour change. "No reaction" is a complete answer worth marks: check the order in the group before you write any equation.

Transition elements

The **transition elements** 过渡元素 are the block of metals in the middle of the Periodic Table. Compared with Group I metals, they:

- have high densities;
- have high melting points;
- form **coloured** 有色 **compounds** 化合物;
- often act as catalysts, both as elements and in compounds.

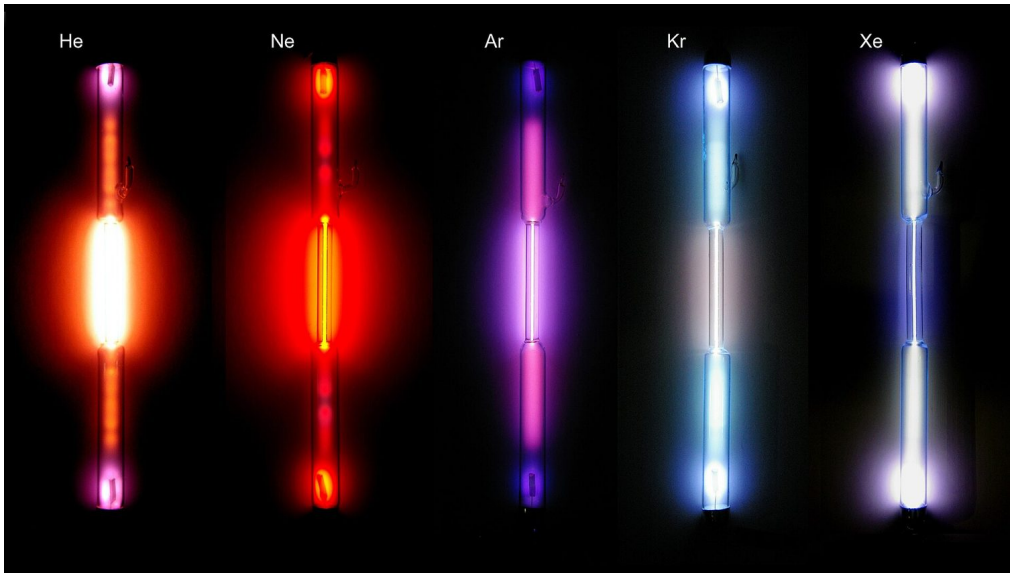
They can also have **variable** 可变 **oxidation numbers** 氧化数. For example, **iron** 铁 forms both iron(II) and iron(III) compounds.

Transition metals form coloured compounds: each of these solutions contains a different transition-metal ion

Group VIII — the noble gases

The Group VIII **noble gases** 稀有气体 are **unreactive** 不活泼, **monatomic** 单原子 gases (they exist as single atoms, not as molecules).

They are unreactive because they already have a full outer shell of electrons. This makes them stable, so they do not need to gain, lose or share electrons.



Passing electricity through each noble gas makes it glow a characteristic colour — this is how neon signs and other lights work

Exam tips

- The Periodic Table is ordered by **proton number**. Elements in the same **group** (column) have the same number of outer electrons, so they react in similar ways; **periods** are the rows.
- **Group I** (alkali metals) get *more* reactive going down; **Group VII** (halogens) get *less* reactive going down — opposite trends.
- A more reactive **halogen displaces** a less reactive one from a solution of its salt — for example chlorine displaces bromine.
- **Noble gases** are unreactive because they have a full outer shell. **Transition elements** are hard and dense, form coloured compounds, act as catalysts and have variable oxidation numbers.