IGCSE CHEMISTRY 0620 · CHAPTER 8 NOTES · ~12 MIN READ

The Periodic Table

The map of all elements: why groups behave alike, why Group I gets more reactive down and Group VII gets less — plus transition elements and the noble gases.

Groups & periods | Group I | Group VII | Transition elements | Noble gases | Trends

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No tag = **Core** (everyone) EXTENDED Extended only highlight = comes up again and again

Test yourself at the end

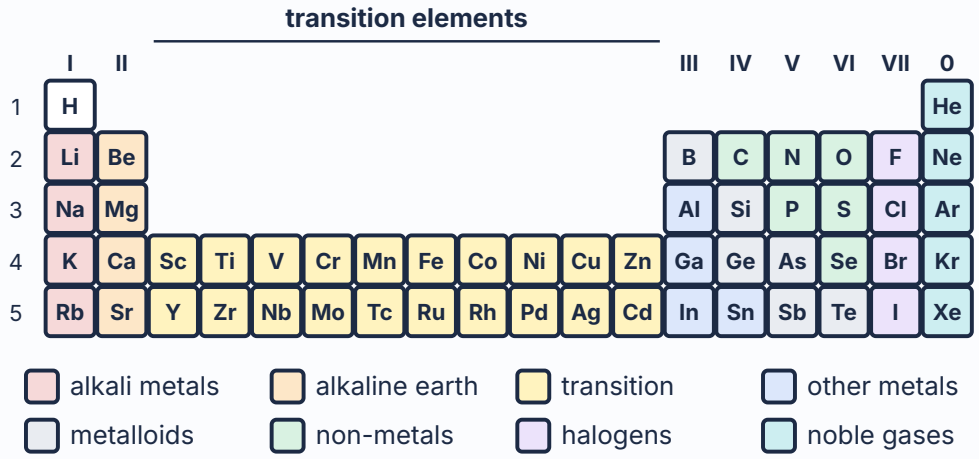
IN 30 SECONDS

- Elements are arranged in order of **proton number**. **Columns (groups)** have the same number of outer electrons, so similar properties. **Rows (periods)** show the number of shells.
- **Group I** metals are **more reactive** as you go **down**. **Group VII** halogens are **less reactive** as you go **down**.
- **Transition elements** are hard, dense metals with high melting points, **coloured** compounds and good **catalysts**.
- **Noble gases** have a **full outer shell**, so they do not react.

BY THE END YOU CAN

- Describe how the table is arranged and link group and period numbers to electrons.
- Describe the trends in Group I and Group VII and predict the properties of other members.
- Describe halogen displacement reactions.
- Describe the properties of transition elements and the noble gases.
- Explain trends using the electronic configuration of atoms. EXT

1 How the table is arranged



group number = outer electrons · period number = number of shells

The first four periods of the Periodic Table with the families colour-coded. Group number = outer electrons; period number = number of shells.

Reading the table

- Elements are in order of **increasing proton number**, from left to right across each period.
- A **group** is a vertical column (I to VII and VIII/0). Elements in the same group have the **same number of outer-shell electrons** and so **similar chemical properties**.
- A **period** is a horizontal row. The period number is the **number of electron shells**.
- **Group number = outer electrons** (for Groups I–VII). Chlorine (2,8,7) → Group VII, Period 3.
- **Group number and ion charge:** Group I → +1, Group II → +2, Group III → +3. Group VI → 2−, Group VII → 1−. Groups IV and V mostly form covalent compounds.

Metals to non-metals

- **Across a period** the elements change from **metals** (left) to **non-metals** (right). A "staircase" line separates them. **Metalloids** (such as silicon) lie along the line and have properties of both.
- The type of oxide changes too: Na_2O and MgO are **basic**, Al_2O_3 is **amphoteric**, SiO_2, P_4O_{10} and SO_2 are **acidic**. See oxides.

Using position to predict

- To predict, find the element in its group and use the **trend**. If you know K and Cs, rubidium (Rb) lies between them.
- EXT You may be given data for some group members and asked to describe the trend or predict a missing value.

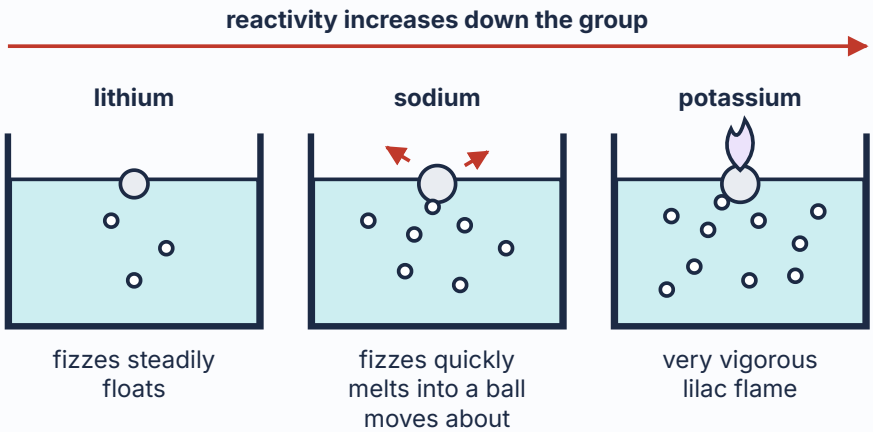
WORKED EXAMPLE

An element has the electronic configuration 2,8,6. Find its group, period and likely ion.

1. 6 outer electrons → **Group VI**
2. 3 shells → **Period 3**
3. it needs 2 electrons to fill its shell → ion X^{2-}
4. **the element is sulfur**

2 Group I — the alkali metals

What they are like



$2Na + 2H_2O \rightarrow 2NaOH + H_2$
alkaline solution: universal indicator turns purple

Lithium, sodium and potassium in water. Reactivity increases down the group. All make hydrogen and an alkaline solution.

- **Soft** metals that can be cut with a knife; shiny when freshly cut but they tarnish quickly in air.
- **Low density** — lithium, sodium and potassium **float** on water.

- **Low melting points** for metals. They **decrease** down the group.
- They form **+1 ions** and **white ionic compounds** that dissolve in water to give colourless solutions.

- Stored under **oil** to keep air and water away.

Element	Melting point (°C)	Density (g/cm³)	With water
lithium	181	0.53	fizzes steadily
sodium	98	0.97	fizzes quickly, melts into a ball
potassium	63	0.86	very vigorous, lilac flame
rubidium	39	1.5	violent, explodes
caesium	29	1.9	explodes

- **Melting points go down** the group. **Density generally goes up** (potassium is an exception). **Reactivity goes up**.
- **Reaction with water:** metal + water → metal **hydroxide** + hydrogen. For example **$2Na + 2H_2O \rightarrow 2NaOH + H_2$**. The solution is **alkaline** — universal indicator turns purple.

Why does reactivity increase down the group? EXTENDED

- A Group I atom reacts by **losing its one outer electron**.
- Down the group the atoms get **bigger**: the outer electron is **further from the nucleus** and more shielded by inner shells, so it is **less strongly attracted** and **easier to lose**.

PICTURE IT

Think of a magnet pulling on a paper clip: when the clip is further away, the pull is weaker and it is easier to remove. The outer electron of caesium is further from the "magnet" than that of lithium.

WORKED EXAMPLE

Predict the melting point and the reaction with water of rubidium, using the table above.

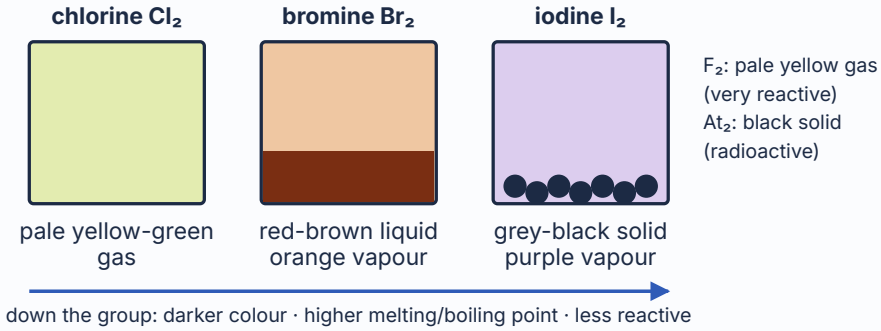
1. The melting points go down the group: K 63 °C and Cs 29 °C, so Rb is **between 29 and 63 °C** (about 39 °C)
2. reactivity increases down the group, so rubidium reacts **more violently than potassium** with water
3. **$2Rb + 2H_2O \rightarrow 2RbOH + H_2$ and the solution is alkaline**

COMMON MISTAKE

Mixing up the trend with Group VII. In Group I, reactivity **increases** down the group.

3 Group VII — the halogens

Diatomic non-metals



F_2: pale yellow gas (very reactive)
At_2: black solid (radioactive)

a more reactive halogen displaces a less reactive one from a salt solution

$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ (turns orange-brown)
$Cl_2 + 2KI \rightarrow 2KCl + I_2$ (turns brown)
$Br_2 + 2KI \rightarrow 2KBr + I_2$ (turns brown)
$Br_2 + KCl \rightarrow$ no reaction (Br_2 is less reactive than Cl_2)

The halogens: chlorine, bromine and iodine. Down the group the colour gets darker and the state changes from gas to liquid to solid. A more reactive halogen displaces a less reactive one.

- The halogens are **non-metals** with **diatomic molecules**: F_2, Cl_2, Br_2, I_2. They have **7 outer electrons** and form **1– ions** (halides: Cl^-, Br^-, I^-).

Halogen	Colour and state at room temperature	Melting and boiling point
chlorine Cl_2	pale yellow-green gas	lowest
bromine Br_2	red-brown liquid (gives orange-brown vapour)	middle
iodine I_2	grey-black solid (gives purple vapour)	highest

- **Down the group:** the colour gets **darker**, the melting and boiling points and **density increase**, and the **reactivity decreases**.
- Fluorine is a very reactive pale yellow gas at the top. Astatine is a black, radioactive solid at the bottom.

- **Predicting astatine:** a **black solid**, with a higher melting point than iodine, **less reactive** than iodine, and forming At^- ions.

Why does reactivity decrease down the group? EXTENDED

- A halogen atom reacts by **gaining one electron** into its outer shell.
- Down the group the outer shell is **further from the nucleus** and more shielded, so the nucleus attracts the incoming electron **less strongly**, and the atom is **less reactive**.

MEMORY TRICK

Group I: the **bigger** the atom, the **easier to lose** an electron, so **more** reactive. **Group VII:** the **smaller** the atom, the **easier to gain** an electron, so **more** reactive. Opposite trends!

Displacement reactions

Displacement — a more reactive element takes the place of a less reactive element in a compound.

- A more reactive halogen **displaces** a less reactive halogen from a solution of its **halide salt**.

	KCl(aq)	KBr(aq)	KI(aq)
chlorine water	no reaction	orange-brown (bromine)	brown (iodine)
bromine water	no reaction	no reaction	brown (iodine)
iodine solution	no reaction	no reaction	no reaction

- $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ (Cl is more reactive than Br).
- $Cl_2 + 2KI \rightarrow 2KCl + I_2$ and $Br_2 + 2KI \rightarrow 2KBr + I_2$.
- EXT Ionic equation: $\mathbf{Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2}$. Chlorine gains electrons (it is reduced) so it is the **oxidising agent**.

WORKED EXAMPLE

Will a reaction happen if bromine water is added to potassium chloride solution? What if fluorine is added to sodium chloride solution?

1. bromine is **less** reactive than chlorine, so it cannot displace chlorine: **no reaction**
2. **fluorine is more reactive than chlorine, so it will displace it: $F_2 + 2NaCl \rightarrow 2NaF + Cl_2$**

COMMON MISTAKE

Writing that a halogen "displaces" a halogen from the **element**. It displaces it from the **halide in solution**.

4 Transition elements

The middle block



Cu^{2+} blue | Fe^{2+} pale green | Fe^{3+} orange brown | MnO_4^- purple

coloured solutions

transition elements:
- high melting points, dense
- compounds are coloured
- act as catalysts (Fe in the Haber process)
- ions with different charges (Fe^{2+}, Fe^{3+})

Transition elements form coloured compounds. Copper(II) is blue, iron(II) is pale green, iron(III) is orange-brown and manganate(VII) is purple.

- **Hard, strong and dense** metals with **high melting points** (mercury is an exception — a liquid).
- **Coloured compounds**: Cu^{2+} blue, Fe^{2+} pale green, Fe^{3+} orange-brown, MnO_4^- purple.
- **Good catalysts**: iron in the Haber process, vanadium(V) oxide in the Contact process, nickel in making margarine.
- EXT **Variable oxidation numbers**: they form ions with **different charges**, for example Fe^{2+} and Fe^{3+} (iron(II) and iron(III)); copper forms Cu^+ and Cu^{2+}.

	Group I	Transition elements
hardness	soft	hard
density	low	high
melting point	low	high
reactivity	very reactive	much less reactive
compounds	white or colourless	usually coloured
ions	one charge only	often more than one charge
catalysts?	no	yes

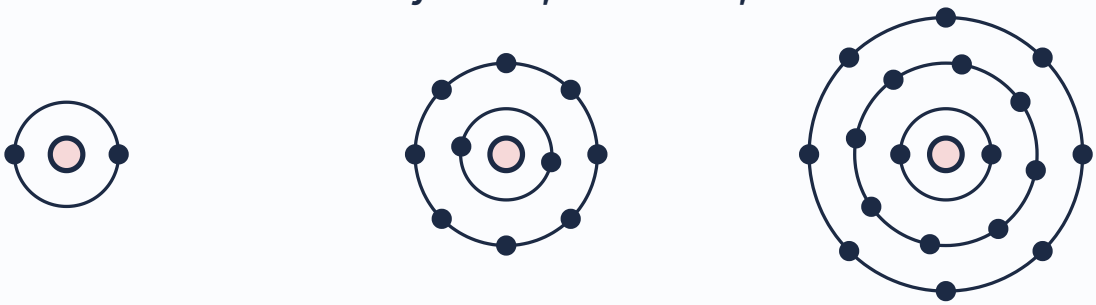
EXAM TIP

Compare Group I with transition elements using **properties** — "soft, low density, low melting point" versus "hard, high density, high melting point".

5 Noble gases

Group VIII (0) — the unreactive gases

full outer shell → very stable, unreactive, monatomic



helium
2
balloons, airships

neon
2,8
bright advertising signs

argon
2,8,8
filament lamps, welding

all are colourless gases · melting and boiling points rise down the group

The noble gases helium, neon and argon. Each has a full outer shell, so the atoms do not bond. They exist as single atoms.

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- The noble gases are **monatomic** (single atoms). They have a **full outer shell** (He 2; others 8), so they do not need to gain, lose or share electrons — they are **very unreactive**.
- All are **colourless gases**. Down the group the **density and boiling point increase**.

Gas	Use	Why
helium	balloons and airships	much less dense than air, and not flammable
neon	advertising signs	glows red-orange when electricity passes through
argon	filament lamps; shielding gas for welding	does not react with the hot metal filament

COMMON MISTAKE

"The noble gases are unreactive because they are gases." They are unreactive because of their **full outer shell**.

6 Compare the trends

Group I and Group VII together

	Group I	Group VII
type	metals	non-metals
outer electrons	1	7
ion formed	+1	−1
reactivity down the group	**increases**	**decreases**
melting point down the group	decreases	increases
appearance	soft grey metals	coloured gases, liquid, solids
why the trend?	outer electron further away, easier to lose	outer shell further away, harder to gain an electron

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7 Test yourself

Test yourself — cover the answers first

QUICK CHECK

1. What is the link between the group number and the electrons in an atom?
2. What does the period number tell you?
3. Name two properties of Group I metals.
4. What are the products when sodium reacts with water?
5. What is the colour and state of bromine at room temperature?
6. Name two properties of transition elements.
7. Why are noble gases unreactive?
8. EXT Why is potassium more reactive than lithium?

EXAM-STYLE

9. Describe what you would see when a small piece of potassium is put on water, and write the equation. [3]
10. Chlorine water is added to potassium iodide solution. Describe the observation and explain it. [3]
11. EXT Explain why the reactivity of the halogens decreases down the group. [3]
12. Predict two properties of astatine. [2]

Show answers

1. group number = number of outer-shell electrons
2. the number of electron shells
3. soft, low density, low melting point, react with water
4. sodium hydroxide and hydrogen
5. red-brown liquid
6. any two from: high melting point, high density, coloured compounds, catalysts
7. they have a full outer shell of electrons
8. the outer electron is further from the nucleus and more shielded, so it is lost more easily
9. floats and moves around, fizzing very vigorously
   burns with a lilac flame
   $2K + 2H_2O \rightarrow 2KOH + H_2$
10. the colourless solution turns brown
    chlorine is more reactive than iodine
    so chlorine displaces iodine from potassium iodide: $Cl_2 + 2KI \rightarrow 2KCl + I_2$
11. a halogen reacts by gaining an electron into its outer shell
    down the group the outer shell is further from the nucleus and more shielded
    so the attraction for an incoming electron is weaker
12. black solid
    less reactive than iodine / higher melting point than iodine

Stuck on a question?

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