Group 7

4.1.2.6 · Atomic structure and the periodic table · revision notes

The halogens in Group 7: their properties and trends, the compounds they form with metals and non-metals, why they get less reactive down the group, and displacement reactions. Higher tier students may also be asked for ionic equations. Displacement and 'explain the trend' questions are very common.

Key facts

- Group 7 = halogens: seven outer electrons; molecules of two atoms (Cl_2)
- Down the group: reactivity decreases
- With metals: ionic halides (1− ions); with non-metals: covalent molecules
- $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ (colourless → orange)
- Down the group: relative molecular mass, melting point and boiling point increase
- Reason: outer shell further from nucleus → weaker attraction → harder to gain an electron
- A more reactive halogen displaces a less reactive one from a solution of its salt
- Grade 8+ only Ionic equation: $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$

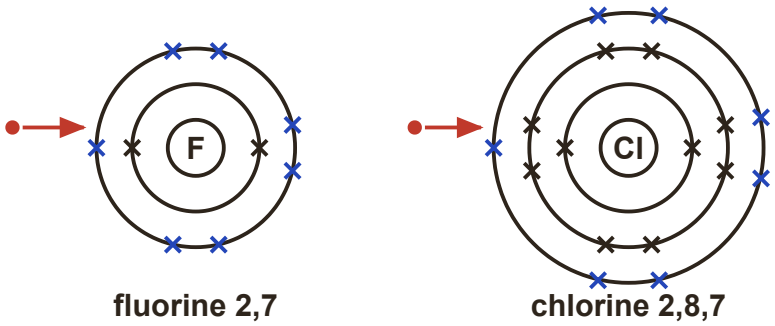
Notes

The halogens

- Group 7 contains fluorine (F), chlorine (Cl), bromine (Br), iodine (I) and astatine (At).
- They are **non-metals** and consist of **molecules made of pairs of atoms**: F_2, Cl_2, Br_2, I_2.
- They all have **seven electrons in their outer shell**, so they have similar reactions. In reactions with metals each atom gains one electron to form a halide ion with a 1− charge, e.g. Cl^-.
- At room temperature: chlorine is a pale green gas, bromine is a red-brown liquid and iodine is a grey-black solid.

Trends down the group

- Going down the group, the **relative molecular mass**, **melting point** and **boiling point** all increase.
- Going down the group, **reactivity decreases**.
- Why: the atoms have more shells, so the outer shell is further from the nucleus. The attraction for an extra electron is weaker, so it is harder for the atom to gain an electron.



fluorine 2,7 **chlorine 2,8,7**

the outer shell of F is nearer the nucleus, so it attracts an extra electron more strongly: F is more reactive

Each halogen atom gains one electron (red) to fill its outer shell.

Compounds of the halogens

- With **metals**, halogens form **ionic compounds** (metal halides) containing halide ions with a 1− charge: 2Na + Cl_2 → 2NaCl.
- With **non-metals**, halogens form **covalent compounds** made of molecules, by sharing electrons: H_2 + Cl_2 → 2HCl (hydrogen chloride).
- Names: chlorine → chloride, bromine → bromide, iodine → iodide.

Displacement reactions

- A more reactive halogen **displaces** a less reactive halogen from an aqueous solution of its salt.
- chlorine + potassium bromide → potassium chloride + bromine: Cl_2 + 2KBr → 2KCl + Br_2. The colourless solution turns orange as bromine forms.
- Chlorine or bromine added to potassium iodide solution turns it brown as iodine forms.
- There is no reaction if the halogen added is less reactive than the one in the salt, e.g. iodine and potassium bromide.
- Ionic equation (Higher tier): the potassium ions are spectator ions, so Cl_2 + $2Br^-$ → $2Cl^-$ + Br_2.

Grade 8+ only

How to answer each type of question

Predict and explain a displacement result

2 to 3 marks | Grade 5

1. Decide which halogen is more reactive (the one higher up the group).
2. A reaction happens only if the added halogen is more reactive than the one in the salt.
3. Give the colour change: orange for bromine, brown for iodine.

Example. A student adds bromine water to potassium chloride solution and to potassium iodide solution.
(a) Which solution reacts? Explain your answer.
(b) What colour does the solution that reacts turn?

Model answer.

(a) Potassium iodide (1). Bromine is more reactive than iodine, so it displaces it, but bromine is less reactive than chlorine (1).

(b) Brown (1)

Write a balanced equation for a displacement reaction

2 marks | Grade 6

1. The halogens are X_2; the salts are metal halides such as NaBr or KI.
2. The two halogens swap places.
3. Balance: you need 2 of the salt for each halogen molecule.

Example. Write a balanced symbol equation for the reaction between chlorine and sodium iodide solution.

Model answer.

$Cl_2 + 2NaI \rightarrow 2NaCl + I_2$

Correct formulae (1); correctly balanced (1).

Explain why reactivity decreases down Group 7

3 marks | Grade 7

1. Compare the number of shells and the distance of the outer shell from the nucleus.
2. Compare the attraction for an extra electron.
3. Say which atom gains an electron more easily.

Example. Explain why chlorine is more reactive than bromine.

Model answer. A chlorine atom has fewer shells, so its outer shell is closer to the nucleus (1). There is a stronger attraction between the nucleus and an electron coming into the outer shell (1). So chlorine gains an electron more easily (1).

Describe the compounds halogens form 2 marks **Grade 5**

1. With a metal: ionic compound, containing halide ions (1−).
2. With a non-metal: covalent compound, made of molecules.

Example. Chlorine reacts with sodium and with hydrogen.
Compare the compounds formed in these two reactions.

Model answer. With sodium, chlorine forms an ionic compound, sodium chloride, which contains Cl^- ions (1). With hydrogen, chlorine forms a covalent compound, hydrogen chloride, made of molecules (1).

Write the ionic equation for a displacement reaction 2 marks **Grade 8**

1. Write the halide ions from the salt and leave out the metal ions (spectator ions).
2. Balance so that the charges are the same on both sides.

Example. Bromine reacts with potassium iodide solution.
Write the ionic equation for this reaction.

Model answer.

$Br_2 + 2I^- \rightarrow 2Br^- + I_2$

Correct particles (1); correctly balanced (1).

Don’t lose marks

- Naming the ion or compound with '-ine': NaBr is sodium bromi**de**, not sodium bromine.
- Writing Cl instead of Cl_2 for chlorine.
- Saying halogen atoms lose electrons. They gain one electron.
- Explaining the trend as for Group 1 ('the electron is lost more easily'). For the halogens it is about gaining an electron.
- Saying iodine displaces chlorine or bromine.

More tips

Memory tricks

- Group 7 is the opposite of Group 1: the halogens get **less** reactive down the group.
- A halogen can displace only the halogens below it in the group.
- The colours get darker down the group: pale yellow (F_2), pale green (Cl_2), red-brown (Br_2), grey-black (I_2).
- Halogen to halide: change '-ine' to '-ide'.

Exam technique

- In displacement questions, first decide which halogen is more reactive, then say whether a reaction happens.
- Explain the trend in three steps: distance of the outer shell → strength of attraction → how easily an electron is gained.
- For a colour change, give the colour the solution turns (orange or brown), not the colour of the halogen you added.
- Higher tier: in ionic equations leave out the spectator ions (e.g. K^+, Na^+) and check the charges balance.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Recall the halogens and their states**
At room temperature chlorine is a green gas, bromine a red-brown liquid and iodine a grey-black solid.

Grade 4 — **Describe the trends down Group 7**
Relative molecular mass, melting point and boiling point increase; reactivity decreases.

Grade 5 — **Describe the compounds halogens form**
Ionic compounds with metals (halide ions, 1−); covalent molecules with non-metals, e.g. HCl.

Grade 5 — **Predict whether a displacement reaction happens**
A more reactive halogen displaces a less reactive one from a solution of its salt.

Grade 6 — **Write equations for displacement reactions**
e.g. $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$, with the colour change.

Grade 7 — **Explain why reactivity decreases down Group 7**
The outer shell is further from the nucleus, so an electron is attracted less strongly and gained less easily.

Grade 8 — **Write ionic equations for displacement (Higher tier)**
Leave out the spectator metal ions, e.g. $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$.

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