Edexcel GCSE Chemistry

Your notes

Group 7

Contents

Group 7 (Halogens)

Your notes

Physical Properties in Group 7

- The elements in group 7 are known as the halogens
  - These are fluorine, chlorine, bromine, iodine and astatine
- These elements are non-metals that are **poisonous**
- All halogens have similar reactions as they each have seven electrons in their outermost shell
- Halogens are **diatomic**, meaning they form molecules made of pairs of atoms sharing electrons (forming a single covalent bond between the two halogen atoms)

Trends in Physical Properties

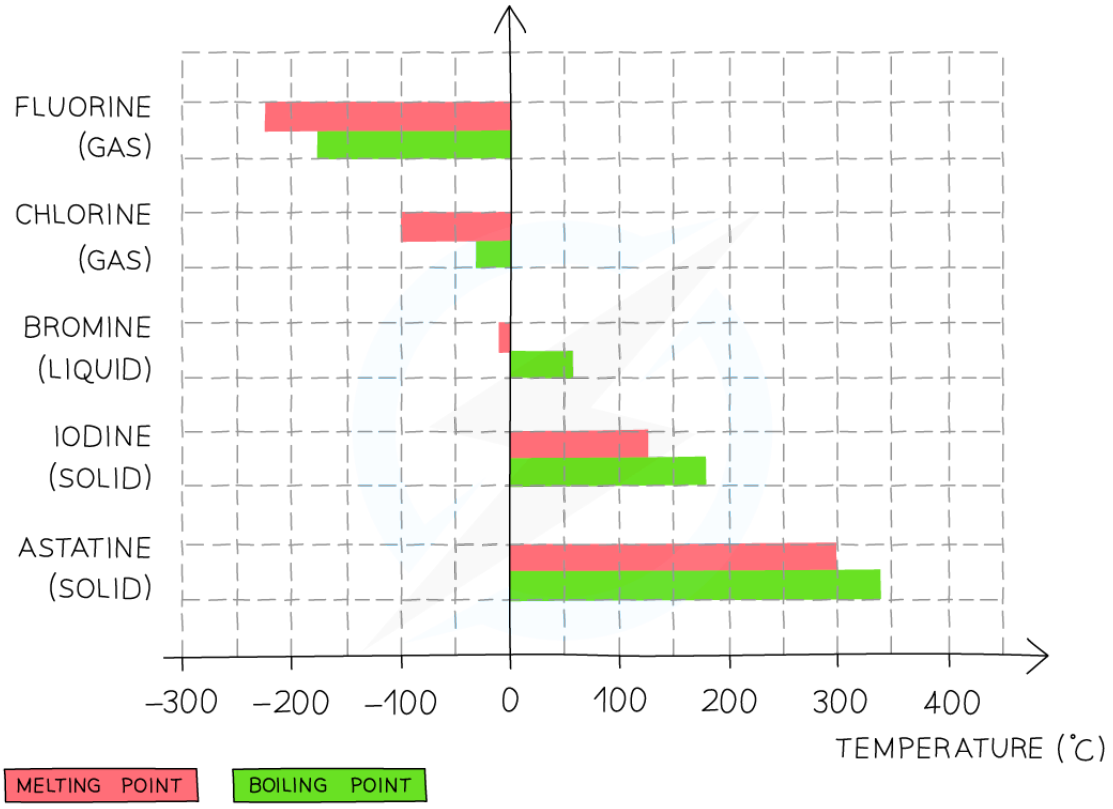
- At room temperature, the halogens exist in different states and colours, with different characteristics

The Appearance, Characteristics and Colour in Solution of the Halogens

Halogen	State & Appearance at Room Temperature	Characteristics	Colour in solution
Fluorine	Yellow gas	Very reactive, poisonous gas	–
Chlorine	Pale yellow–green gas	Reactive, poisonous and dense gas	Pale green
Bromine	Red–brown liquid	Dense red–brown volatile liquid	Orange
Iodine	Grey solid	Shimmery, crystalline solid, sublimes to form a purple vapour	Dark brown

- The melting and boiling points of the halogens **increase** as you go down the group
- This is due to increasing intermolecular forces as the atoms become larger, so more energy is required to overcome these forces

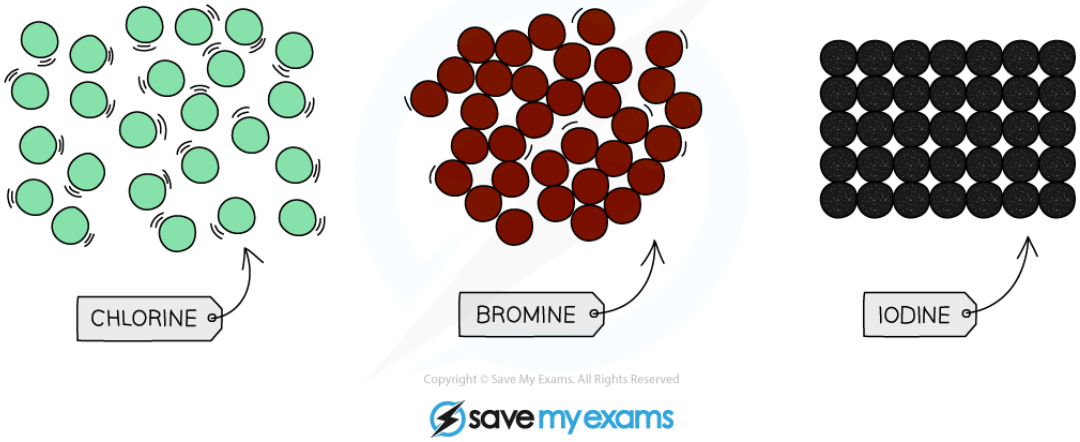
Your notes



This graph shows the melting and boiling points of the group 7 halogens

- At room temperature (20 °C), the physical state of the halogens changes as you go down the group
  - Fluorine and chlorine are **gases**, bromine is a **liquid** and iodine is crumbly **solid**
- The colours of the halogens also change as you descend the group - they become darker

Your notes



The physical states and colours of chlorine, bromine and iodine at room temperature

Examiner Tips and Tricks

Exam questions on this topic occur often so make sure you know and can state the trends of the group 7 elements in detail.

Testing Chlorine

- The test for chlorine makes use of **litmus paper**
- If chlorine gas is present, damp blue litmus paper will be **bleached white**
- It may turn red briefly before bleaching, as acids are produced when chlorine comes into contact with water
- Chlorine should always be handled in a fume cupboard due to its toxicity

Your notes

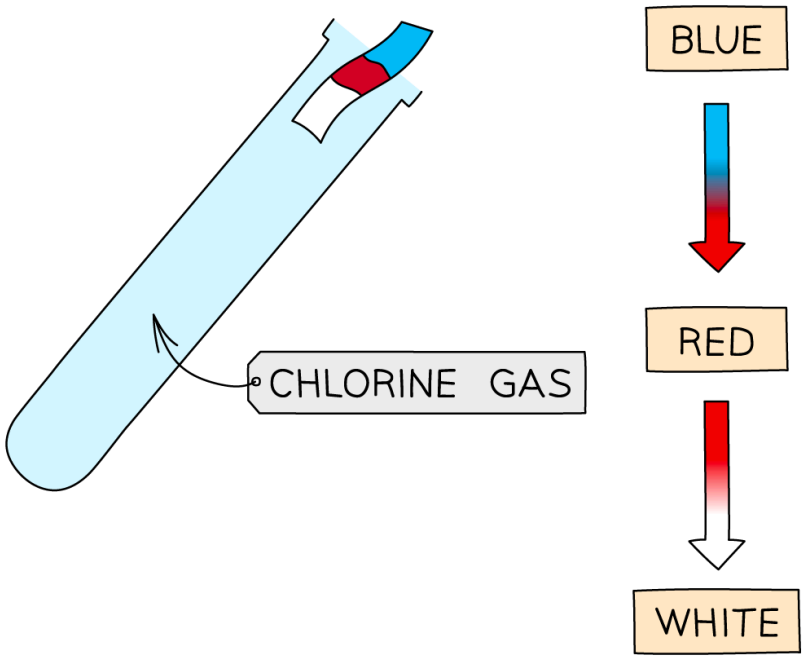


Diagram showing the test for chlorine gas

Examiner Tips and Tricks

You should distinguish between properties of gases and tests for gases. Chlorine 'smells like swimming pools' is a characteristic, but not an acceptable means of identification. You can use blue, red or universal indicator paper to show the bleaching effect.

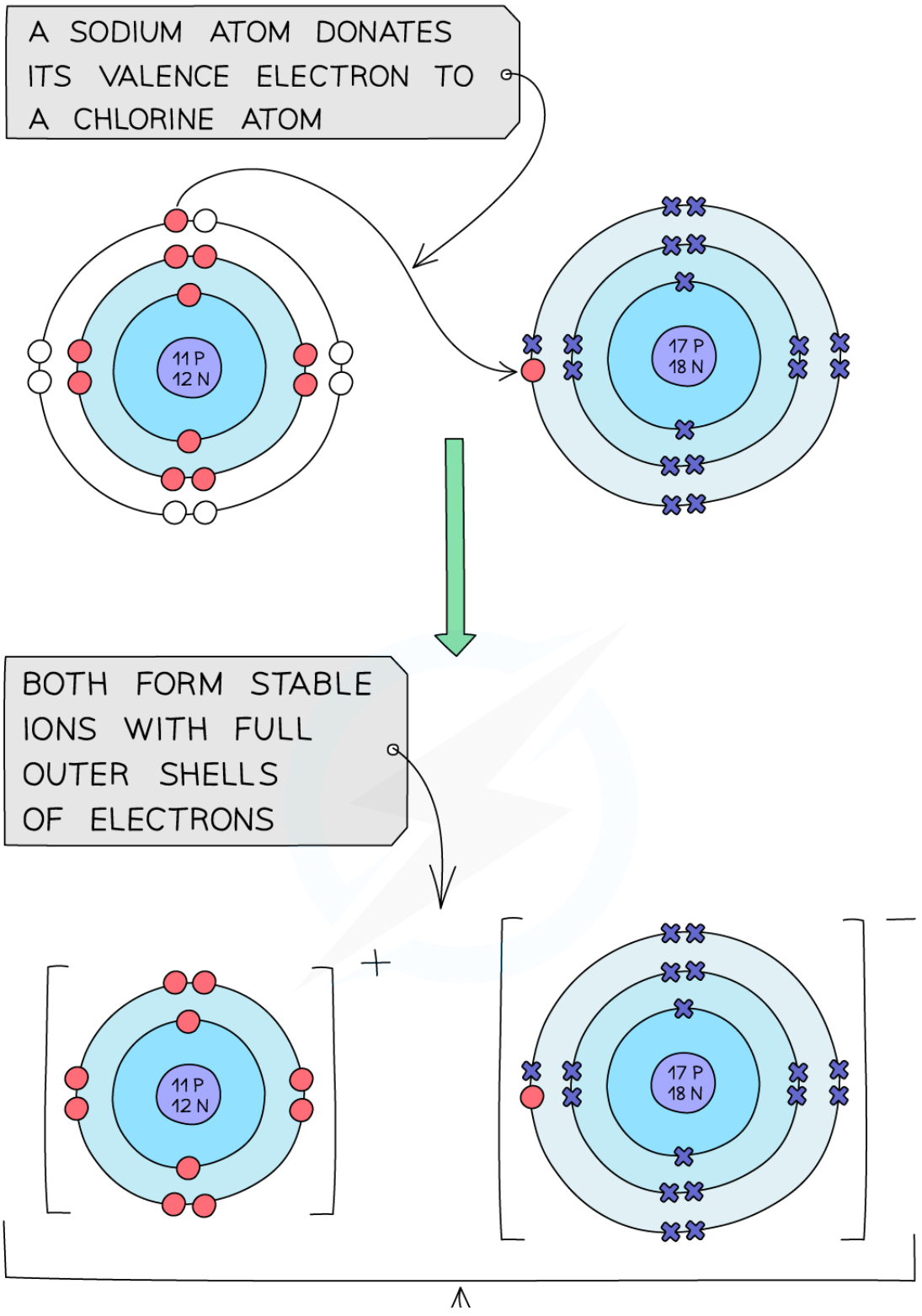
Your notes

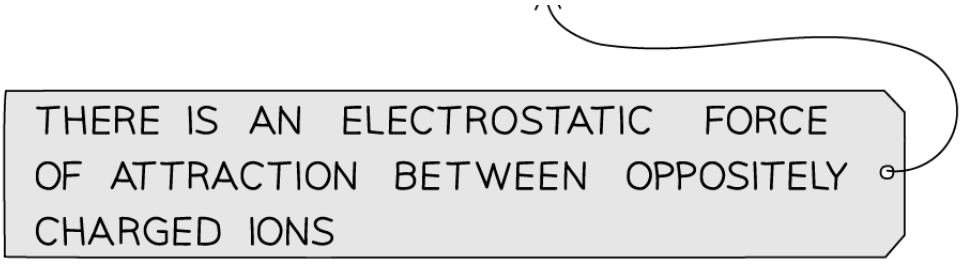
Reactions with Metals

Metal Halides

- The halogens react with some metals to form **ionic compounds** which are **metal halide salts**
- The halide ion carries a -1 charge so the ionic compound formed will have different numbers of halogen atoms, depending on the **valency** of the metal
- E.g., sodium is a group 1 metal:
  - $2\,Na + Cl_2 \rightarrow 2\,NaCl$
- Calcium is a group 2 metal:
  - $Ca + Br_2 \rightarrow CaBr_2$
- The halogens **decrease** in **reactivity** moving down the group, but they still form halide salts with some metals including iron
- The rate of reaction is **slower** for halogens which are **further** down the group such as bromine and iodine

Your notes

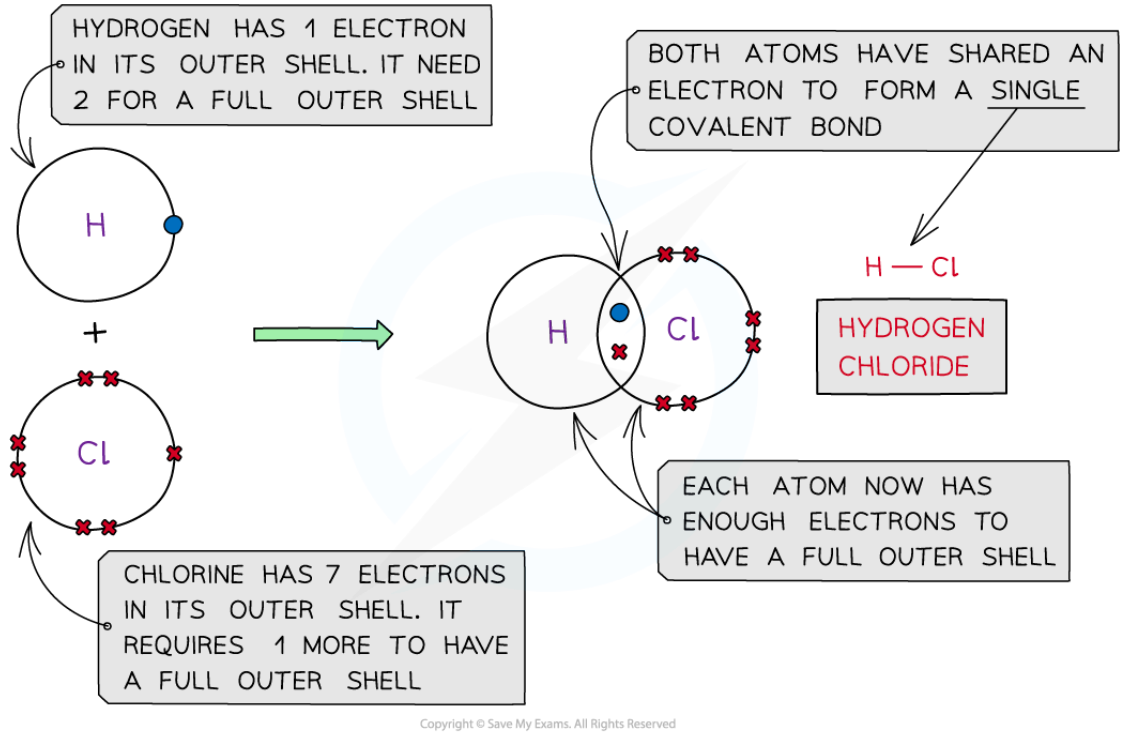




Sodium donates its single outer electron to a chlorine atom and an ionic bond is formed between the positive sodium ion and the negative chloride ion

Hydrogen Halides

- The halogens react with nonmetals to form simple molecular covalent structures
- For example, the halogens react with hydrogen to form **hydrogen halides** (e.g., hydrogen chloride)



Hydrogen chloride is a simple covalent molecules made by direct combination of hydrogen and chlorine

Your notes


Your notes

- Hydrogen halides are steamy acidic gases that dissolve very well in water to form strongly acidic solutions
- For example, hydrogen chloride gas dissolves in water to form hydrochloric acid:

$$HCl\,(g) \longrightarrow HCl\,(aq)$$

- The other hydrogen halides will do the same, although strangely enough, hydrofluoric acid is actually a weak acid in water

Trends in reactivity and stability

- Reactivity decreases down the group, so iodine reacts less vigorously with hydrogen than chlorine (which requires light or a high temperature to react with hydrogen)
- Fluorine is the most reactive (reacting with hydrogen at low temperatures in the absence of light)
- The hydrogen halides becomes less stable as you go down the group, so much so that hydrogen iodide decomposes quite readily on heating:

$$2HI\,(g) \rightleftharpoons H_2\,(g) + I_2\,(g)$$

- This pattern illustrates an important principle in chemistry about stability and reactivity: the more vigorous and energetic a reaction forming a compound is, the more stable in the product, and vice versa

Displacement Reactions

- A **halogen displacement reaction** occurs when a more reactive halogen displaces a less reactive halogen from an aqueous solution of its halide
- The reactivity of group 7 elements decreases as you move down the group
- You only need to learn the displacement reactions with chlorine, bromine and iodine
  - Chlorine is the most reactive and iodine is the least reactive

Chlorine with Bromides & Iodides

- If you add chlorine solution to colourless potassium bromide or potassium iodide solution a displacement reaction occurs:
  - The solution becomes orange as bromine is formed or
  - The solution becomes brown as iodine is formed
- Chlorine is **above** bromine and iodine in group 7 so it is more reactive
- Chlorine will **displace** bromine or iodine from an aqueous solution of the metal halide:

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

chlorine + potassium bromide → potassium chloride + bromine

$$Cl_2 + 2KI \rightarrow 2KCl + I_2$$

chlorine + potassium iodide → potassium chloride + iodine

Bromine with Iodides

- Bromine is above iodine in group 7 so it is **more** reactive
- Bromine will displace iodine from an aqueous solution of the metal iodide

bromine + potassium iodide → potassium bromide + iodine

$$Br_2 + 2KI \rightarrow 2KBr + I_2$$

- **This table shows a summary of the displacement reactions of the halogens: chlorine, bromine and iodine**

	Chlorine (Cl_2)	Bromine (Br_2)	Iodine (I_2)
Potassium chloride (KCl)	X	No reaction	No reaction
Potassium bromide (KBr)	Chlorine displaces the bromide ions. Yellow–orange colour of bromine is seen	X	No reaction
Potassium iodide (KI)	Chlorine displaces the iodide ions. Brown colour of iodine is seen	Bromine displaces the iodide ions:. Brown colour of iodine is seen	X

- From this pattern of reaction we can predict that:
  - Fluorine will **displace** all other halogens from their compounds
  - Astatine will **be displaced** by all the halogens from its compounds
- Having said that, astatine is the rarest naturally occurring element so there is not enough around to actually test!

Your notes

Examiner Tips and Tricks

Displacement reactions are sometimes known as single replacement reactions.

Your notes

Your notes

Halogen Displacement & Redox

- Recall that oxidation and reduction take **place together** at the **same time** in the **same reaction**
- Oxidation is **loss** of electrons and reduction is the **gain** of electrons
- Halogen displacement reactions are **redox reactions**
- This can be seen if we analyse in more detail the displacement of iodine by chlorine in the following reaction:

$$Cl_2 + 2KI \rightarrow 2KCl + I_2$$

chlorine + potassium iodide → potassium chloride + iodine

- The full ionic equation is:

$$Cl_2 + 2K^+ + 2I^- \rightarrow 2K^+ + 2Cl^- + I_2$$

- The K^+ ions are **spectator ions** as they appear on both sides of the equation unchanged so can be eliminated. The net ionic equation is thus:

$$Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$$

- If we now analyse each half equation, we can see that each chlorine atom has been **reduced** as an electron is **gained** on changing from the chlorine molecule to chloride ions:

$$Cl_2 + 2e^- \rightarrow 2Cl^- \quad \text{REDUCTION}$$

- Each iodide ion has been **oxidised** as an electron is **lost** on changing from iodide ions to the iodine molecule:

$$2I^- \rightarrow I_2 + 2e^- \quad \text{OXIDATION}$$

- This shows that halogen displacement reactions are **redox processes**

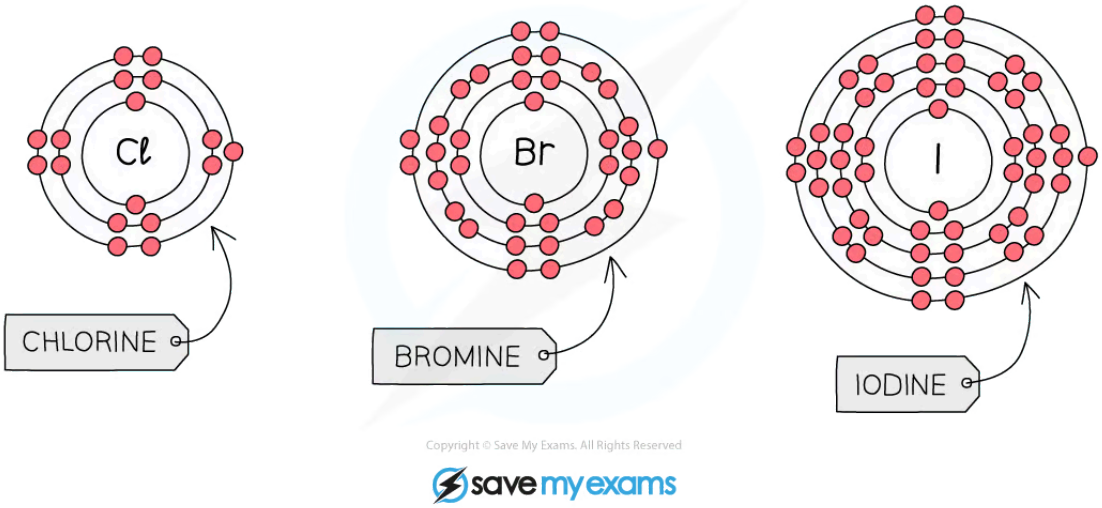
Examiner Tips and Tricks

The more reactive halogen undergoes reduction, the less reactive one undergoes oxidation.

Your notes

Group 7: Reactivity & Electronic Configurations

- When halogen atoms gain an electron during reactions, they form -1 ions called halide ions
- We can use electronic configuration to explain the trends in chemical reactivity down group 7



The atoms of the elements of group 7 all have 7 electrons in their outer shell

- Reactivity of group 7 non-metals **decreases** as you go down the group
  - As you go down group 7, the number of shells of electrons **increases**, the same as with all other groups
- However, halogen atoms form negative ions when they **gain an electron** to obtain a full outer shell
  - This means that the increased distance from the outer shell to the nucleus as you go down a group makes the halogens become **less reactive**
- Fluorine is the smallest halogen, which means its outermost shell is the **closest** to the positive nucleus of all the halogen
  - Therefore, the ability to **attract an electron** is strongest in fluorine making it the most reactive
  - As you move down the group, the forces of **attraction** between the nucleus and the outermost shell **decreases**

- This makes it **harder** for the atoms to gain electrons as you descend the group
- Therefore, the halogens are less reactive the further down the group you go

Examiner Tips and Tricks

Exam questions on this topic occur often so make sure you know and can explain the reactivity trends of the group 7 elements in detail, using their electron configurations.

Your notes