BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Topic C7: Group Chemistry

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There are some groups which you need to know about in more detail. These are:

- ➔ Group 1 - The Alkali Metals
- ➔ Group 17 - The Halogens
- ➔ Group 18 - The Noble Gases

Group 1: The Alkali Metals

Group 1 metals, such as lithium, sodium and potassium, all have only 1 electron in their outer shell. This makes **group 1 metals very reactive** because **1 electron can be easily lost**.

There are some general trends in the properties of group 1 that you are expected to know. As you go down group 1:

- **Reactivity increases** - The atomic number increases as you go down the group, meaning that atoms have **more electron shells** as you progress down the group. Therefore, the electron in the outer shell is **lost more easily** because it is **more shielded** from the attraction of the **positive nucleus.**
- In terms of increasing reactivities, Potassium > Sodium > lithium.
- Potassium is the most reactive and so the reaction with water will be the most violent.
- **Density increases** because the atoms now have more protons in the nucleus, increasing the attraction of the electrons.
- **Melting point** and **boiling points decrease** because there are more electron shells and so the attraction of the nucleus on the delocalised electrons is weaker as you go down the group. Hence less energy is required to overcome it and so melting and boiling points are lower.

The group 1 metals **form ionic bonds with non-metals**. The alkali metals will have an oxidation state of +1 in ionic compounds.

The Group 1 metals are known as the alkali metals because they all form alkaline compounds.

- **Group 1 Metal + Oxygen → Metal oxide**
  - The freshly cut surfaces of group 1 metals are shiny and silver, but these surfaces will become dull quite quickly as it reacts with oxygen in the air
- **Group 1 Metal + Water → Metal hydroxide + Hydrogen gas**
  - The hydrogen gas produced can be detected putting a lighted splint over the solution- a “squeaky pop” will be heard indicating the hydrogen gas is present.
  - The metal hydroxide produced is alkaline.
  - E.g. $2K_{(s)} + 2H_2O_{(l)} \rightarrow 2KOH_{(aq)} + H_{2(g)}$

Group 17: The Halogens

The halogens **exist as diatomic molecules**, such as Cl_2. The two halogen molecules are joined together by **1 covalent bond.**

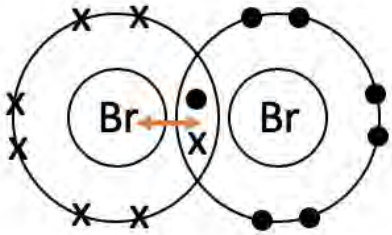
The halogens include fluorine, chlorine, bromine and iodine.

Halogen	Coloured Vapour	State
Fluorine	Yellow	Gas
Chlorine	Green	Gas
Bromine	Red-Brown	Liquid
Iodine	Dark grey (can have purple vapour)	Solid

All halogens have **7 electrons in their outer shell**.

Again, there are trends in the properties of group 17 that you should learn:

- **Reactivity decreases** as you go down group 17.This is because there are more shells between the positive nucleus and the outer shell of electrons decreasing the attraction of the nucleus. This means that it is harder to gain an additional electron.
- **Relative oxidising strength** also decreases down the group. This is the ability to oxidise other atoms - causing them to lose electrons.
- **Melting and boiling points increase** down the group.This is explained by the **increasing atomic size** which increases the intermolecular **Van der Waal forces** between molecules. More energy is required to overcome these forces and so the melting and boiling points increase.
- This means that the physical state of the halogens changes down the group; fluorine is a gas going down to iodine which is a solid.
- **Electronegativity decreases** as you go down group 17. This is the ability to attract the **shared pair of electrons** in a covalent bond. This reduces as you move down the group as the shared pair of electrons are further from the nucleus and so are attracted less strongly.



Electronegativity is the ability of an atom to attract the shared pair of electrons in a covalent bond.

Reaction with **metals**:

The **halogens** react with **Group 1** Alkali metals by ionic bonding to form salts known as **metal halides**.

Example

Potassium + chlorine → potassium chloride

$2K + Cl_2 \rightarrow 2KCl$

Displacement reactions of halogens:
More reactive halogens will **displace** (take the place of) **less reactive** halogens. Less reactive halogens are halogens that are **lower** in the periodic table since reactivity of the halogens **decreases** down the group.

Chlorine is **more reactive** than bromine and iodine, meaning chlorine will displace bromide or iodide in solution, to form chloride ions and bromine or iodine:

Halogen	What does it displace?	What is the equation?	Is there a colour change?
Chlorine	Bromide	$Cl_{2\,(aq)} + 2Br^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + Br_{2(aq)}$	Orange solution
	Iodide	$Cl_{2\,(aq)} + 2I^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + I_{2(aq)}$	Brown solution
Bromine	Iodide	$Br_{2(aq)} + 2I^-_{(aq)} \rightarrow 2Br^-_{(aq)} + I_{2(aq)}$	Brown solution
Iodide	None	N/A	N/A

Iodine is the furthest down the group and so is the least reactive out of these halogens.

➔ For this reason it **will not displace F^-, Cl^- or Br^-** and so there will be no reaction between an iodine solution and a solution containing these ions.

Bleach

- Bleach is sodium chlorate(I); $NaClO_{(aq)}$. It is used in the treatment of water; to bleach paper and textiles, and for household cleaning.
- It is formed by **mixing chlorine gas** with **dilute sodium hydroxide** at **room temperature.**

Group 18: The Noble Gases

The noble gases have a **full outer shell of electrons**.

➔ Since the noble gases have full outer shells of electrons, they are **not very reactive;** they are **inert**. This is because they **do not try to lose or gain electrons to increase their stability**.

At room temperature, the noble gases exist as **colourless gases** which are **non-flammable.** The low flammability is due to the fact that they are inert.

Boiling points and density increase as you move down the group due to the larger size. This increases the size of intermolecular forces, increasing the boiling point. It increases the number of protons in the nucleus, decreasing the atomic radius and thus increasing the density.

Examples of noble gases include helium, neon and argon.

- Argon is used in filament light bulbs to provide an inert atmosphere. Because argon is both non flammable and prevents the filament burning, the hot filament inside the light will not burn away and set fire to the light bulb.
- Helium has a lower density than air and is unreactive, making it good to use in balloons to make them float.

Transition Metals

- Form **colourful compounds**:
  - Iron (II) compounds are light green.
  - Iron (III) compounds are brown/orange.
  - Copper compounds are blue.
- Are useful **catalysts** in industry:
  - Iron is used as the catalyst to make ammonia in the Haber process.
  - Nickel is the catalyst for the hydrogenation of alkenes.
- **Some transition metals can form more than one ion.**
  - For example, iron can form a Fe^{2+} ion (iron(II)) or an Fe^{3+} ion (iron(III)).

Exam tip:
It is useful to know the colours of the compounds formed by each of the transition metals.