Introduction

Elements with similar electron configurations have some similar properties. We're now going to look at the periodic table and discuss which properties are similar. But first, what do we mean by "similar electron configurations"? We mean atoms that have their **valence electrons** in similar subshells. For example, all the atoms that had one "s" electron (and nothing else) in their outer shell would have a similar electron configuration. With that in mind, let's look at the main-group atoms and see how their properties are similar.

Group IA: the alkali metals

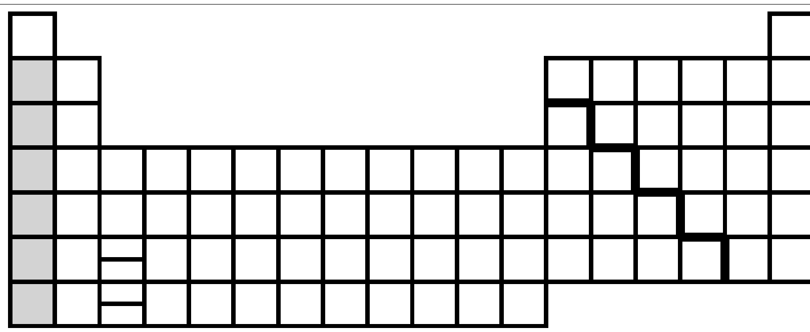

Illustration 1 - The alkali metals: Li, Na, K, Rb, Cs, Fr

Notes:

- Found in **group IA**
- Valence electrons: **ns^1**, where n = the period number

Shown in gray above, the alkali metals are all **soft, very reactive metals**. They will all react with H_2O to produce H_2 gas by a single replacement reaction:

$$2M + 2H_2O \rightarrow 2MOH + H_2(g)$$

These reactions are usually violent and very exothermic. Think of the reaction between sodium metal and water. The heavier the alkali metal, the more violent its reaction with water.

Oxides of these metals have the formula M_2O and form **basic** solutions in water (will turn litmus paper **blue**).

[One of the defining characteristics of a ***metal*** *is that its oxide has basic properties.* ***Nonmetal*** *oxides are acidic.]*

Group IIA: the alkaline earth metals

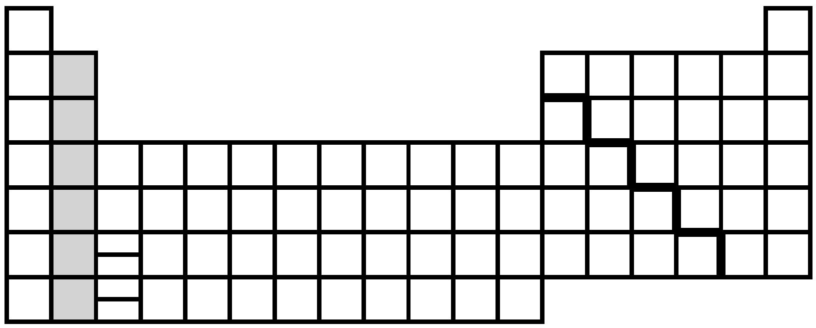

Illustration 2 - The alkaline earth metals: Be, Mg, Ca, Sr, Ba, Ra

Notes:
- Found in **group IIA**
- Have valence electrons **ns²**

Shown in gray above, the alkaline earth metals (sometimes just called the alkaline metals) are soft and reactive metals, but not as soft or reactive as the corresponding alkali metal. Most of the alkaline earth metals react with water like the alkali metals, but not as rapidly.

$$M + 2H_2O \rightarrow M(OH)_2 + H_2(g)$$

Oxides of these metals have the formula MO and have **basic** properties.

Group IIIA elements

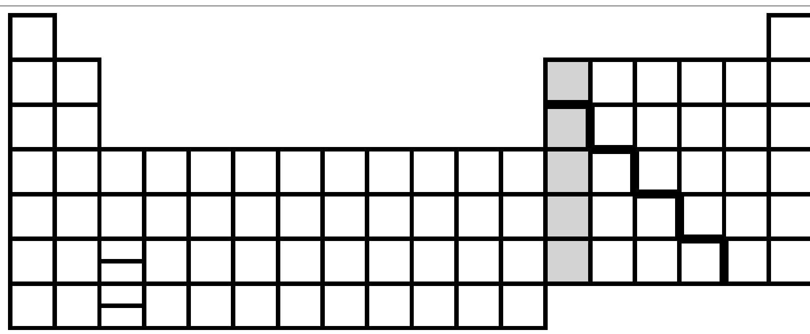

Illustration 3 - The group IIIA elements: B, Al, Ga, In, Tl

Notes:
- Have valence electrons: $\mathbf{ns^2np^1}$

Shown in gray above, the group IIIA elements are mostly metals. Boron is considered a metalloid (semiconductor), as it has properties in common with both metals and nonmetals. The other group IIIA elements are metals, including the familiar aluminum. Gallium is known for its melting point - a metal with a melting point near human body temperature. Gallium will melt in your hand.

Unlike the alkali and alkaline metals, these elements **do not react** directly with water to produce hydrogen gas.

The **oxides** of these elements have the form M_2O_3. Unlike the alkali and alkaline earth metals, the oxides are not all basic. Boron's oxide is **acidic**, suggesting that boron is closer to being a nonmetal than a metal. Aluminum and gallium oxides are amphoteric, meaning that they can act as either an acid or a base. The other group IIIA oxides are basic (meaning that the other elements are clearly metals).

Group IVA elements

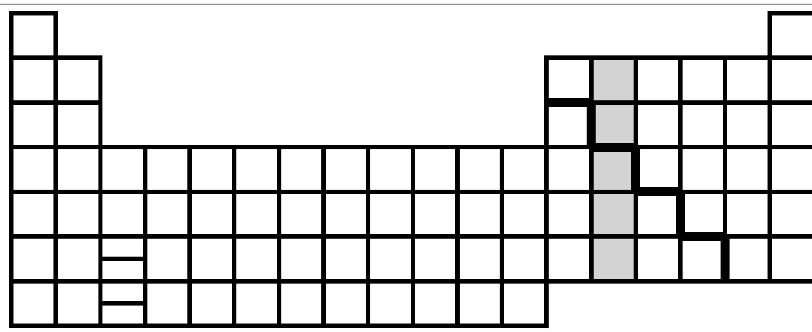

Illustration 4: The group IVA elements: C, Si, Ge, Sn, Pb

Notes:

- Have valence electrons: $\mathbf{ns^2np^2}$

Shown in gray above, the group IVA elements range from nonmetals (carbon) to metalloids (silicon and germanium) to metals (tin and lead).

These elements don't react with water to produce hydrogen gas.

Oxides of the group IVA elements range from acidic to amphoteric. This suggests that even the metals of group IVA do not have as much metallic character as do the other metals we have discussed so far. Formulas of the oxides tend to be MO_2, but carbon and lead also form MO.

Group VA elements

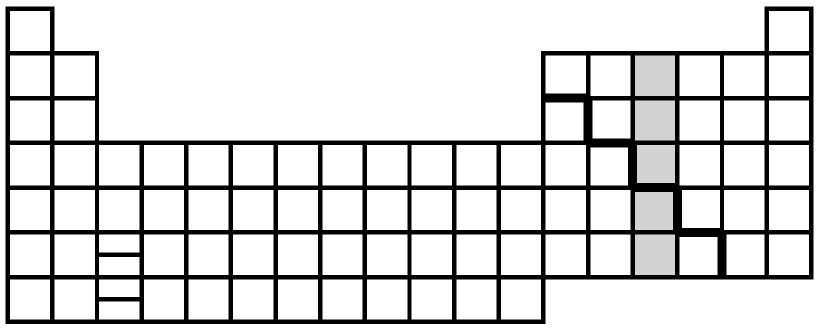

Illustration 5: The group VA elements: N, P, As, Sb, Bi

Notes:

- Have valence electrons: ns^2np^4

The group VA elements (like the group IVA elements) vary from nonmetallic to metallic. There's only one metal here (bismuth). The other elements are nonmetals (nitrogen and phosphorus) or metalloids (arsenic and antimony).

These elements don't react with water to produce hydrogen gas.

Oxides of these elements have many forms - common are RO_2 and RO_3. These oxides are acidic for the nonmetals, amphoteric for the metalloids, and basic for bismuth.

Nitrogen is a gas, while the other group VA elements are solids.

Group VIA: The chalcogens

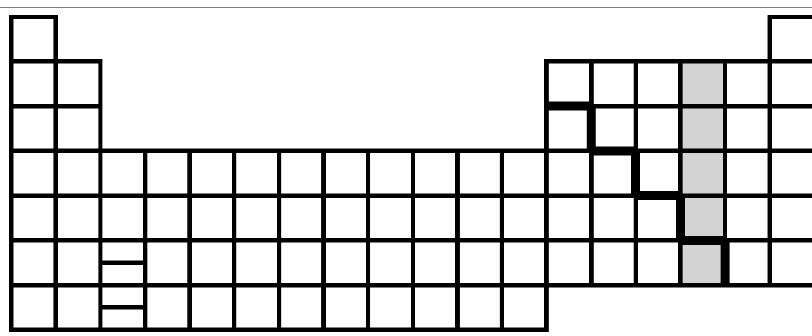

Illustration 6: The chalcogens: O, S, Se, Te, Po

Notes:

- Found in **group VIA**
- Have valence electrons: ns^1np^4

- The name means "ore producer". Many ores contain oxygen or sulfur.

The chalcogens, like the previous group, range from nonmetals (oxygen, sulfur, selenium) to metalloids (tellurium) to metals (polonium). You're familiar with the common chalcogens - oxygen and sulfur. Oxygen is a gas, while the rest of the chalcogens are solids.

These elements don't react with water to form hydrogen gas.

The **oxides** of these elements (like the group IVA elements) may have varying formulas. RO_2 and RO_3 are common. The oxides range from acidic to amphoteric as you move down the column.

Group VIIA: The halogens

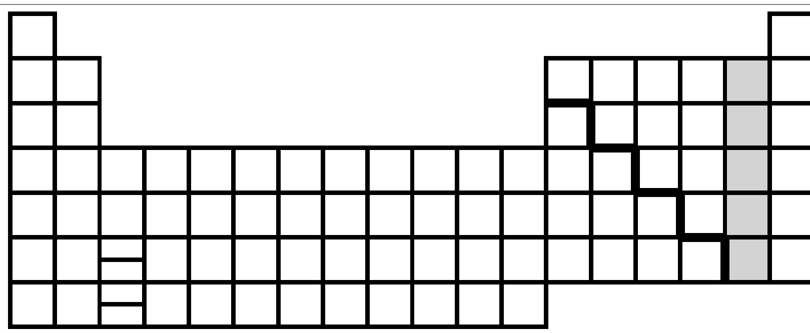

Illustration 7: The halogens: F, Cl, Br, I, At

Notes:
- Found in **group VIIA**
- Have valence electrons: $\mathbf{ns^2np^5}$
- The name means "salt producer". Think of the formula of table salt.

The halogens are all reactive nonmetals. Most of the elements should be familiar to you, particularly fluorine, chlorine, and iodine. Chemically, the halogens tend to react alike. In pure form, they exist as diatomic molecules (e.g. Cl_2). Halogens range in physical form from gaseous at room conditions (fluorine, chlorine) to liquid (bromine) to solid (iodine and astatine). Astatine, however, is very unstable and wasn't even **isolated** until 1940!

These molecules react with water to form acids like HCl and HOCl. This is **different chemistry** from the metals (which produce a hydroxide and hydrogen gas as products).

Oxides of the halogens are unstable, but acidic.

Group VIII: The noble gases

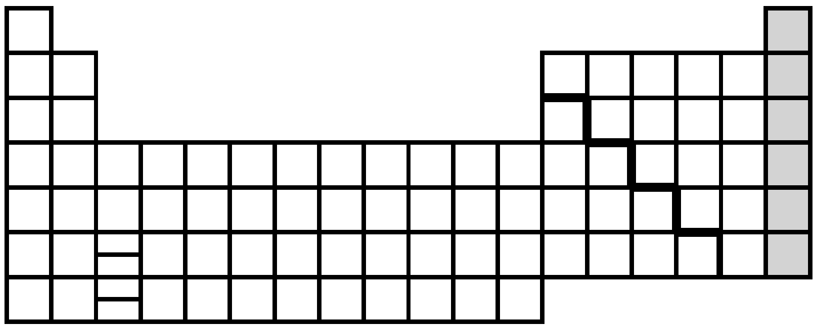

Illustration 8: The noble gases: He, Ne, Ar, Kr, Xe, Rn

Notes:

- Found in **group VIIIA**
- Have valence electrons: $\mathbf{ns^2np^6}$ *(the s and p subshells are full!)*

The noble gases are all **nonmetals**. They normally exist in nature as single, uncombined gas atoms. They are called the noble gases because they are all very unreactive. Only krypton, xenon, and radon are even known to form compounds (and many of these are rare in nature). Since the noble gases are unreactive, most of the compounds that can be formed from them involve them combining with very reactive species like oxygen and fluorine.

Noble gases are used in lighting (neon signs), and they are useful when unstable compounds need to be surrounded by an **inert** atmosphere.

Summary

We hope you've enjoyed your trip through the main group elements. Please wait until the note pack comes to a complete stop before disembarking.

In this note pack, we've summarized the important properties of the main group elements and noted some similarities (and differences) between the elements in each group. You should have an idea now of what the elements in the periodic table are like based on their location - no matter whether you've heard of them before or not.