1.10: Periodic Trends for the Main Group Elements

Within the main group (s- and p-block) elements of the Periodic Table (Figure 1.10.1.66) there are some general trends that we can observe for the elemental form, as well as the hydrides, oxides, and halides.

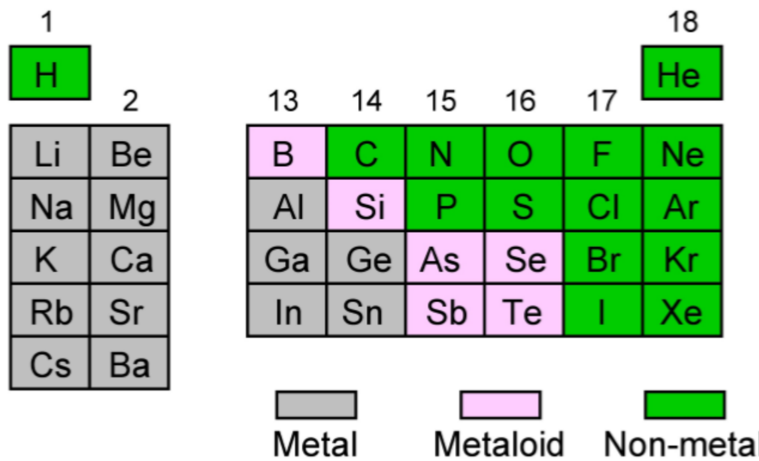

Figure 1.10.66: The main group elements (Adapted from www.meta-synthesis.com).

Periodic trends for the main group elements

Within the main group (s- and p-block) elements there are some general trends that we can observe.

- The further down a given Group the elements have increased metallic character, i.e., good conductors of both heat and electricity, and exhibit delocalized bonding.
- Moving from left to right across a Period the elements have greater non-metallic character, they are insulators with localized bonding.
- Within the p-block at the boundary between the metallic elements (Figure 1.10.1.66, grey elements) and nonmetal elements (Figure 1.10.1.66, green elements) there is positioned boron and silicon that are metalloid in character (Figure 1.10.1.66, pink elements), i.e., they have low electrical conductivity but it increases with temperature.

As an example of these changes Table 1.10.1.12 shows the trends across one Period.

Table 1.10.1.12: Summary of trends for elements across the Periodic Table.

Element	**Na**	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Properties	Electropositive metal	Electropositive metal	Metal but forms covalent bonds	Metalloid semiconductor or metal/non-metal characteristics	E-E bonding in elements	E-E bonding in elements	Simple molecule	Monoatomic gas

Periodic trends for the main group hydrides

The properties of main group hydrides are dependant on the difference in electronegativity between the element and hydrogen (Table 1.10.1.13). Elements on the left of the Periodic Table are highly electropositive and form ionic hydrides, while those of the center and right are covalent in character. However, of those with covalent E-H bonds, there is a change from polymeric hydrides to molecular compounds. For example, the Group 13 element hydrides (i.e., BH_3) form hydrogen-bridged oligomers (i.e., B_2H_6). In contrast, HCl is a diatomic molecule.

Table 1.10.1.13: Summary of properties of selected main group hydrides as a function of the relative electronegativities.

Hydride	Element electronegativity	Hydrogen electronegativity	E-H polarity	Structure	Comments
NaH	0.9	2.1	M^+H^-	Ionic	Reacts with H_2O to liberate H_2
BH_3	2.0	2.1	$B^{\delta+}$-$H^{\delta-}$	Oligomeric and polymeric	Reacts slowly with H_2O
CH_4	2.4	2.1	$C^{\delta-}$-$H^{\delta+}$	Molecular	Insoluble in H_2O
HCl	3.0	2.1	$Cl^{\delta-}$-$H^{\delta+}$	Molecular	Dissolves in H_2O to form H^+ and Cl^-

Periodic trends for the main group oxides

As with hydrides the properties of main group oxides are dependant on the difference in electronegativity between the element and oxygen. Highly electropositive metals for ionic oxides, while other elements for covalent bonds (albeit polar in character) with oxygen. In addition, the aggregation of covalent oxides decreased across the Period from left to right (Table $1.10.1.14$). As may also be seen from Table $1.10.1.14$, oxides of elements on the left of the Periodic Table dissolve in water to form basic solutions, while those on the right form acidic solutions. There is a class of oxides (especially those of Group 13 and 14) that can react as either an acid or a base. These are known as amphoteric substances.

> **Note**
>
> The word is from the Greek prefix *ampho* meaning "both"

Table 1.10.1.14: Comparison of oxides across the Periodic Table.

Oxide	Bonding	Reactivity with H_2O	Description
Na_2O	Ionic	Dissolves to give a strong base	Basic
Al_2O_3	Covalent polymeric	Dissolves in both acidic and basic solution	Amphoteric
SiO_2	Covalent polymeric	Dissolves in both acidic and basic solution	Amphoteric
CO_2	Covalent molecular	Dissolves to give a weak acid	Acidic
SO_3	Covalent molecular	Dissolves to give a strong acid	Aci

In summary, oxides of the main group elements show two trends.

1. From left to right across a Period, the oxides change from ionic → oligomeric/polymeric covalent → molecular covalent
2. From left to right across a Period, the oxides change from ionic → oligomeric/polymeric covalent → molecular covalent.

Periodic trends for the main group chlorides

The trend between ionic and non-ionic/covalent in moving across a Period is also true for the chlorides of the main group elements. Those on the left (i.e., Group 1 and 2) are ionic and soluble in water, while those to the right tend to give acidic solutions due to reactions with the water and the formation of hydrochloric acid, e.g., (1.10.1).

$$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl_{(aq)} \tag{1.10.1}$$