S-BLOCK ELEMNTS

PREREQUISITE

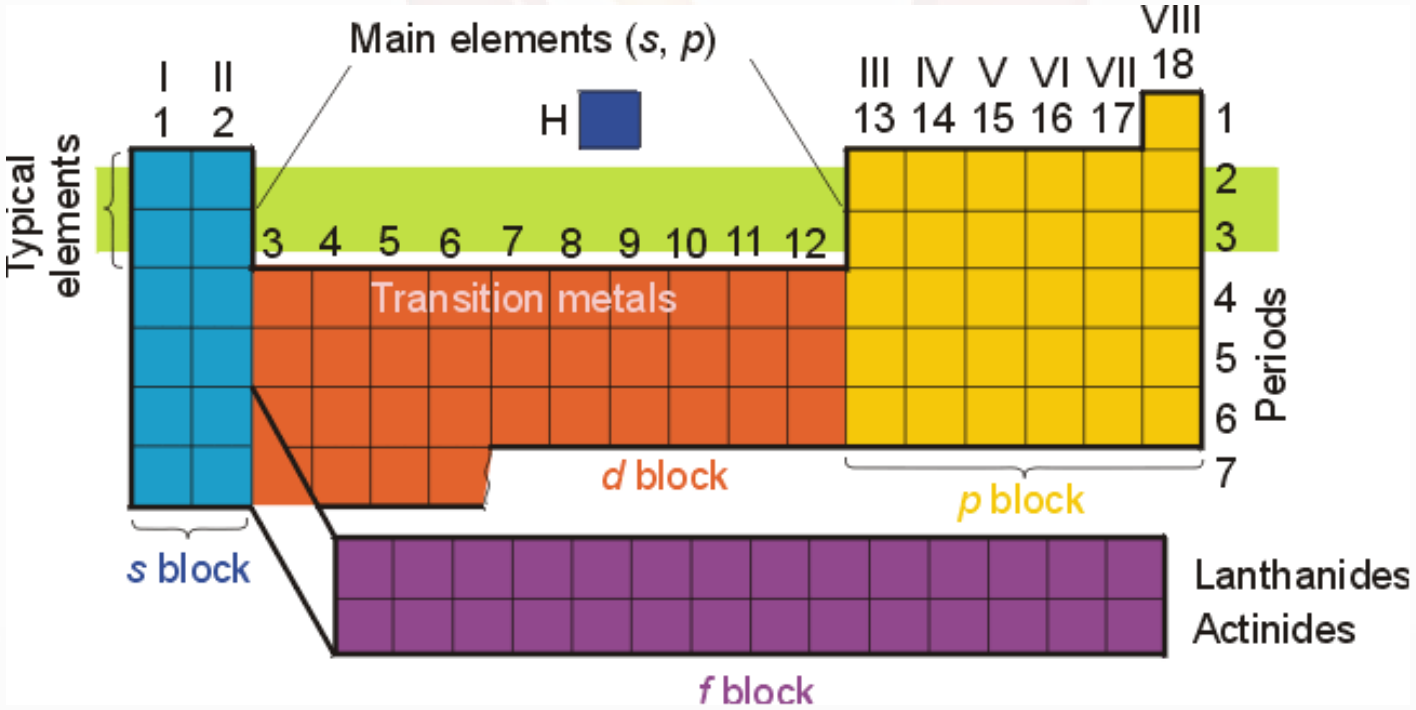
- Electronic configuration of elements
- Periodic trends

LEARNING OUTCOME

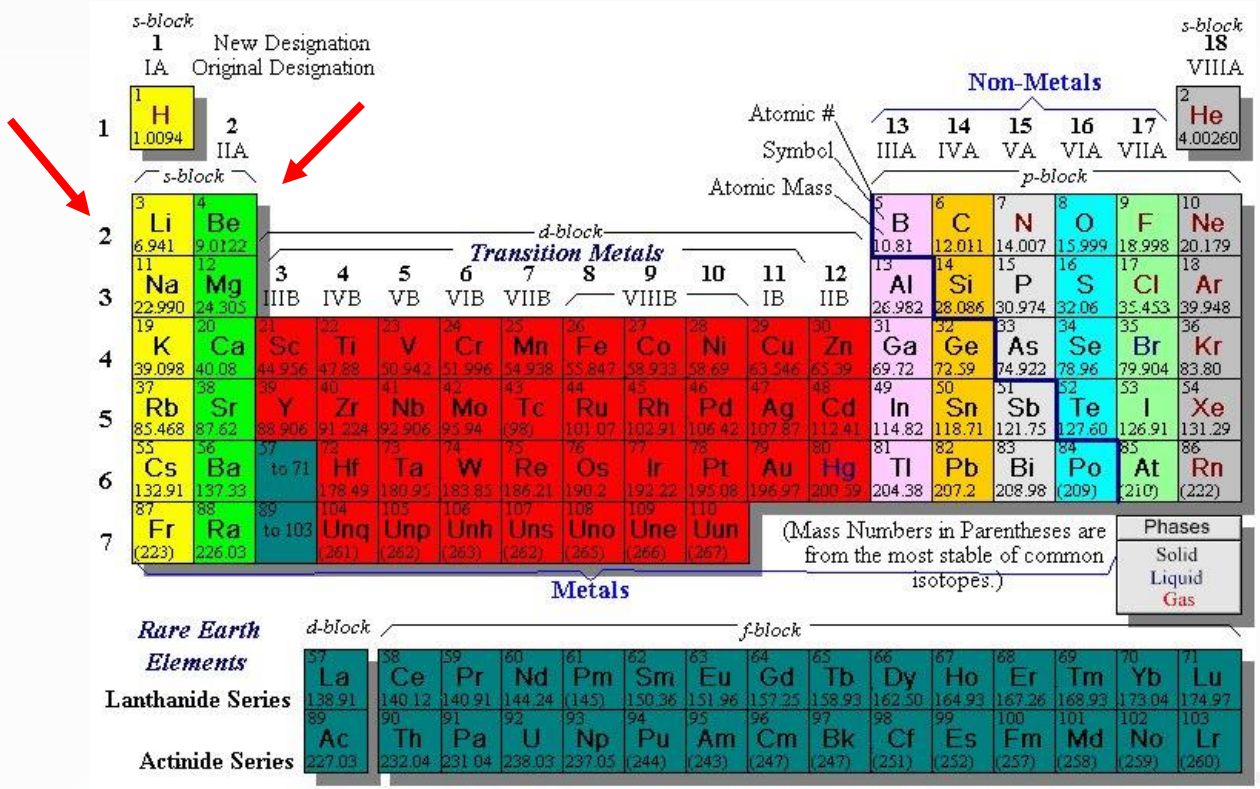
- Knowledge of s-block elements
- Properties and complex formation

Selected Aspects of Main Group Chemistry

For the rest of the course, we will look at some aspects of the chemistry of main group compounds. The basic principles that you have learned concerning atoms, molecules and bonding (covalent and ionic) can be used to understand the reactivity and structures that are observed for elements and compounds throughout the periodic table. We only have time to look at some examples from the groups that comprise the Main group (the s-block and the p-block elements).



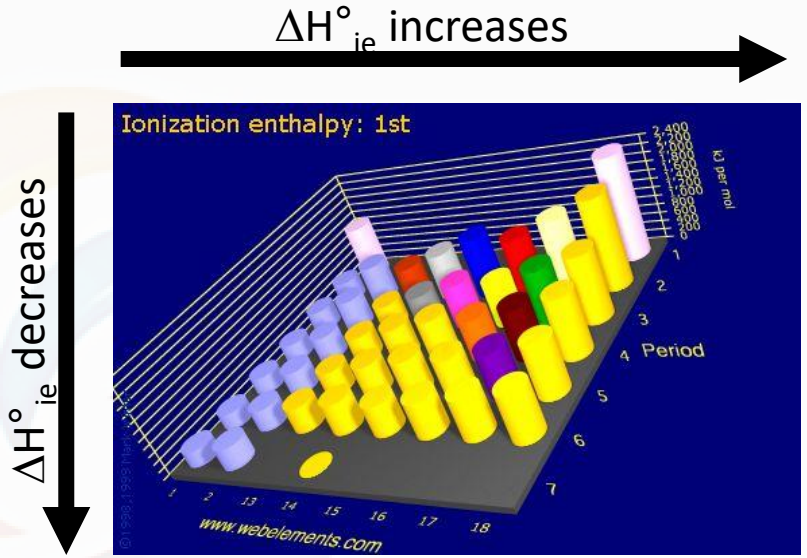
Group 1 - Alkali metals
Group 2 - Alkaline earth metals



Much of the important chemistry of the alkali and alkaline earth metals can be understood on the basis of their low ionization enthalpies (or electronegativities) and the favourability of ionic bonding.

Group 1 - Alkali metals
Group 2 - Alkaline earth metals

The s-block elements lose their electrons more easily than the other element in the main group so they are usually strong reducing agents and most tend to form ionic compounds. The stabilization that is provided by the crystal lattice (or hydration) energy of the salts they make helps to favour many reactions.



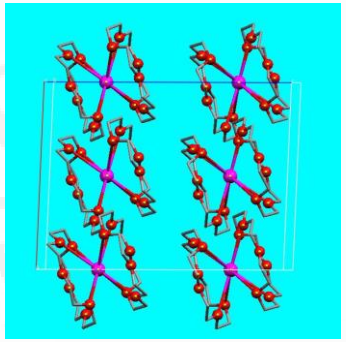
One of the stranger consequences of the low ionization enthalpy is observed when some of the group 1 metals are dissolved in appropriate solvents, such as liquid ammonia:

E.g.: $Na_{(s)}$ (dissolved in $NH_{3\ (l)}$) $\rightarrow$ $Na^{+}_{(am)} + e^{-}_{(am)}$

At low concentration this is a blue solution that contains solvated electrons! If the reaction warms up or is catalyzed, the free electron reacts with the solvent to produce hydrogen gas:

$$Na^{+}_{(am)} + 2\ (NH_2)^{-}_{(am)} + H_{2(g)}$$

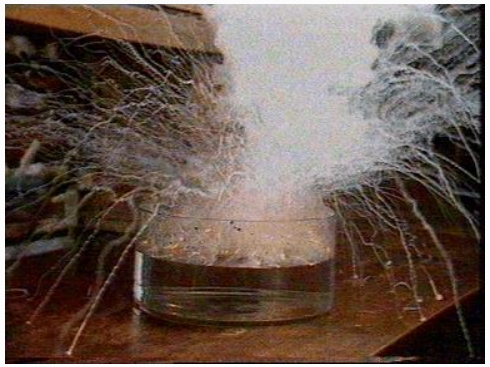
This demonstrates the reducing ability of the alkali metals and is a very common and useful property of these elements.



X-ray crystal structure of $[Cs^{+}L_2][e^{-}]$

Group 1 - Alkali metals
Group 2 - Alkaline earth metals

The s-block metals are used as reducing agents for an immense number of different types of compounds.



Reactions of the elements with water:

Group 1: $M_{(s)} + H_2O_{(l)} \rightarrow M^+_{(aq)} + (OH)^-_{(aq)} + ½\ H_{2(g)}$

Group 2: $M_{(s)} + 2\ H_2O_{(l)} \rightarrow M^{+2}_{(aq)} + 2\ (OH)^-_{(aq)} + H_{2(g)}$

These reactions are very exothermic and increase in violence from the lightest to the heaviest elements in the group (enough to ignite the H_2 for the heavier elements). The non-reversible nature of this reaction means that such metals are very useful for drying many kinds of solvents.

More generally:

Group 1: $M_{(s)} + HOR \rightarrow M^+ + (OR)^- + ½\ H_{2(g)}$

Group 2: $M_{(s)} + 2\ HOR \rightarrow M^{+2} + 2\ (OR)^- + H_{2(g)}$

These reactions make metal alkoxides that are very useful for the synthesis of other products using *metathesis* reactions. Metathesis indicates that the reagents exchange ligands with one another. Such reactions are especially favourable when it produces a metal halide because of the large exothermicity provided by the lattice or hydration energies.

e.g.'s $MOR + ClPR'_2 \rightarrow MCl + R'_2POR$

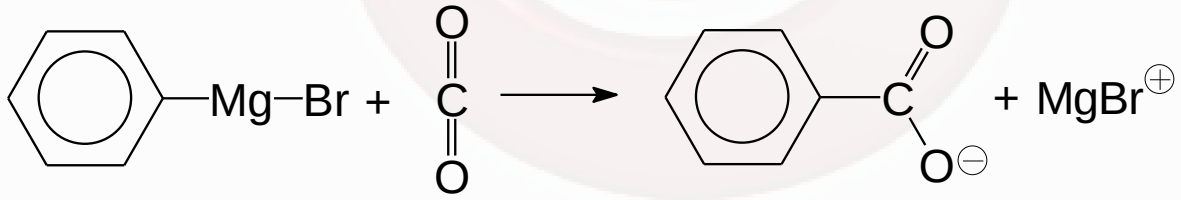
$MNR_2 + ClSiR'_3 \rightarrow MCl + R'_3SiNR_2$

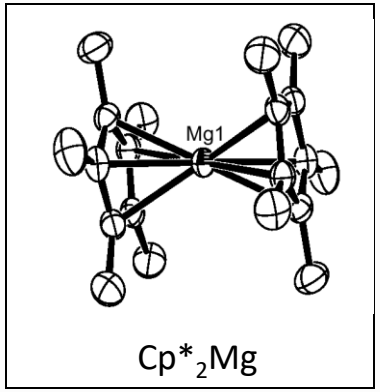
Group 1 - Alkali metals
Group 2 - Alkaline earth metals

One of the most important discoveries in synthetic chemistry was made by Victor Grignard (Nobel Prize 1912) following the initial work of others. He showed that the reaction of Mg with organic iodides (RI, later applied to other halides) results in the insertion of the Mg into the R-I bond. This provides a reagent of the form R-Mg-I that can be used in nucleophilic or metathesis reactions to make new carbon-carbon bonds.

$$Mg_{(s)} + R\text{-}I \rightarrow R\text{-}Mg\text{-}I$$

$$R\text{-}Mg\text{-}I + I\text{-}R \rightarrow R\text{-}R + MgI_2$$





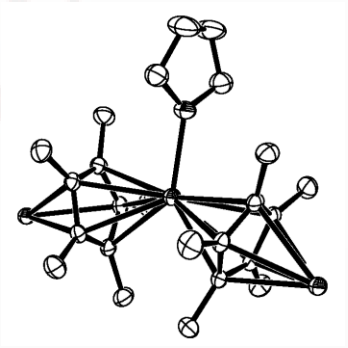
Cp^*_2Mg

Analogous and more reactive reagents can be made with Li and Na.

$$2\ Li_{(s)} + R\text{-}X \rightarrow R\text{-}Li + Li\text{-}X \quad (X = \text{halide})$$

$$R\text{-}Li + X\text{-}R' \rightarrow R\text{-}R' + Li\text{-}X$$

Such compounds were among the first that were recognized to contain bonds between metals and carbon. These were thus some of the initial examples of *organometallic* chemistry (one of the most studied branches of inorganic chemistry today).



$(Cp^*Na{\bullet}THF)_\infty$

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THANK YOU