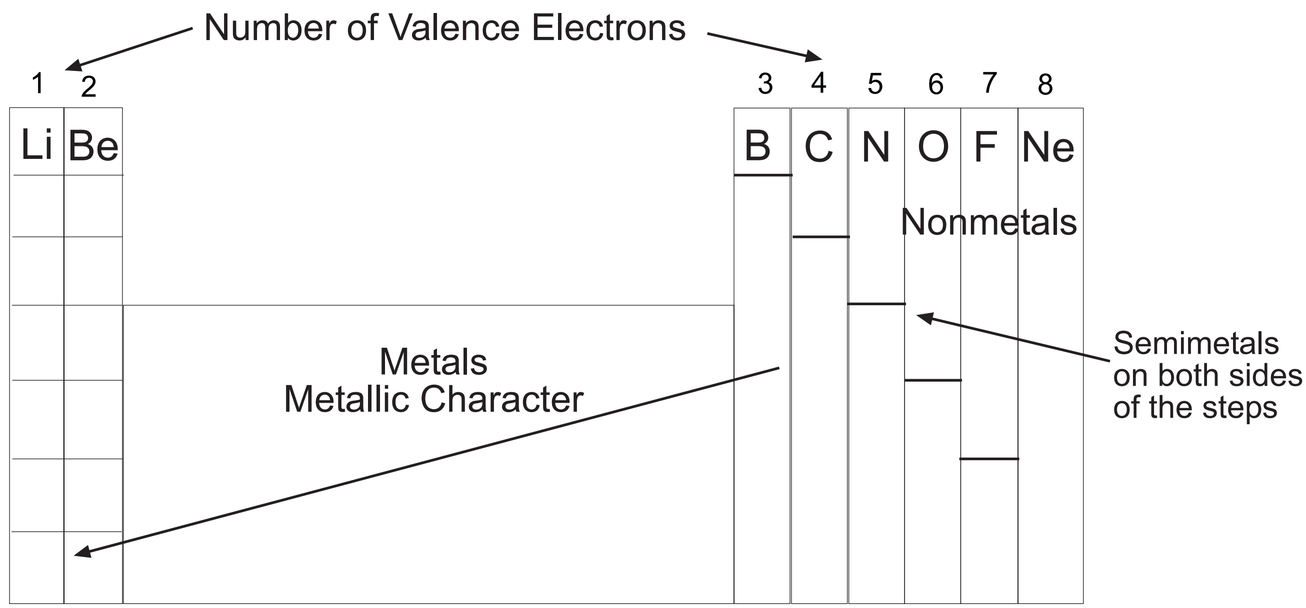
Teacher's Tools® Chemistry

Atoms and electrons: The Periodic Table: Student Review Notes

The Periodic Table is an organization of elements by chemical similarity.

Periodic Law is the idea that physical properties change in a regular fashion as you move across a period and that chemical properties of the members of a group are similar—that's what defines the groups. You should understand that this similar reactivity comes from the fact that **members of a group have the same valence electron configuration** and chemical reactivity has a lot to do with valence electrons.



Hydrogen

Valence Shell: $1s^1$

Hydrogen doesn't really fit into a group. It has the same number of valence electrons as the alkali metals but it is not a metal. At standard state conditions, hydrogen exists as a diatomic gas, H_2. Unlike the alkali metals, hydrogen can form both a positive and negative ion.

Hydrogen as a +1 cation: H_2O

Hydrogen as a -1 anion: NaH

Hydrogen has three isotopes ${}^1_1H$ (hydrogen), ${}^2_1H$ (deuterium, symbol D), and ${}^3_1H$ (tritium, symbol T).

Group IA Elements: Alkali Metals

Valence Shell: ns^1 The chemistry of the Group IA metals is characterized by the single electron in the outer s-orbital.

Li
Na
K
Rb
Cs
Fr

Group IA metals

- Have low Ionization Energies
- Almost always form a +1 cation
- Are never found in a pure state in nature
- React with water to produce hydrogen gas and a basic solution

$$\underbrace{2M_{(s)}}_{\text{Group IA metal}} + H_2O_{(l)} \longrightarrow 2MOH_{(aq)} + H_{2(g)}$$

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Group 2A Elements: Alkali Earth Metals

Valence Shell: ns^2 The chemistry of the Group 2A metals is characterized by a full outer s-orbital.

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Be
Mg
Ca
Sr
Ba

Group 2A metals

- Tendency to form +2 cations
- Less reactive than the alkali metals
- Reactivity varies down the group with increasing size. The larger the group IIA element the more likely it is to lose its two valence electrons.
- Be does not react with water
- Mg reacts with steam (water with a lot of kinetic energy)
- Ca, Sr, and Ba react with water to give off hydrogen gas and form a basic solution

$$\underbrace{M_{(s)}}_{\text{Ca, Sr, or Ba}} + 2H_2O_{(l)} \longrightarrow Ba(OH)_{2(aq)} + H_{2(g)}$$

Group 3A Elements

Valence Shell: ns^2np^1 The chemistry of the elements of Group 3A is characterized by 3 valence electrons.

B	metalloid
Al	metals
Ga	metals
In	metals
Tl	metals

Boron does not form binary ionic compounds. The molecular compounds that it does form are exceptions to the octet rule. For example, BH_3 and BF_3 are stable covalently bonded molecules in which boron is surrounded by 6, not 8, electrons.

Aluminum is a metal that will form an oxide when exposed to oxygen:

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow Al_2O_{3(s)}$$

Aluminum is also oxidized by acids with the release of hydrogen gas:

$$2Al_{(s)} + 6H^{+}_{(aq)} \longrightarrow 2Al^{3+}_{(aq)} + 3H_{2(g)}$$

Group 4A Elements

Valence Shell: ns^2np^2 The chemistry of the elements of Group 4A is characterized by 4 valence electrons.

C	nonmetal
Si	metalloids
Ge	metalloids
Sn	metals
Pb	metals

Carbon is a nonmetal, silicon and germanium are metalloids, tin and lead are metals. Carbon, silicon and germanium do not form ionic compounds.
The metals of this group are oxidized by acidic solutions.

$$Sn_{(s)} + 2H^{+}_{(aq)} \longrightarrow Sn^{2+}_{(aq)} + 3H_{2(g)}$$

$$Pb_{(s)} + 2H^{+}_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + 3H_{2(g)}$$

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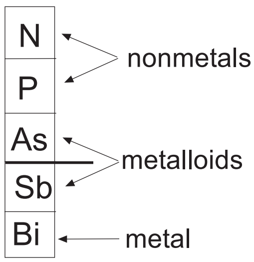
Group 5A Elements

Valence Shell: ns^2np^3 The chemistry of the Group 5A metals is characterized by 5 valence electrons but there is a lot of variation of properties as you go down the group.



Nitrogen is diatomic at standard state conditions: $N_{2(g)}$
Nitrogen's most common oxidation state is N^{3-}
Phosphorous can be P^{3-} or P^{5-} (expanded octet)
Non-metal oxides are acidic in water

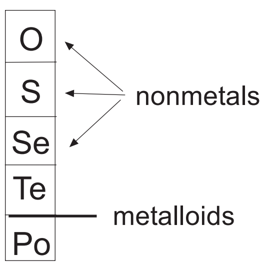
$$N_2O_{5(g)} + H_2O_{(l)} \longrightarrow 2H^{3+}_{(aq)} + 2NO_3^-{}_{(aq)}$$

$$P_2O_{3(g)} + 5H_2O_{(l)} \longrightarrow 6H^{3+}_{(aq)} + 2H_2PO_3^-{}_{(aq)}$$

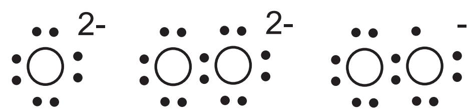
$$P_2O_{5(g)} + 3H_2O_{(l)} \longrightarrow 2H^{3+}_{(aq)} + 2H_2PO_3^-{}_{(aq)}$$

Group 6A Elements

Valence Shell: ns^2np^4 The chemistry of the elements of Group 6A is characterized by 6 valence electrons.



Oxygen is diatomic at standard state conditions: $O_{2(g)}$
Oxygen's most common oxidation state is O^{2-}
Oxygen can also be O_2^{2-} in peroxide or O_2^- in superoxide



oxide peroxide superoxide

The ions all form basic solutions when reacted with water:

$$O^{2-}{}_{(aq)} + H_2O_{(l)} \longrightarrow 2OH^-{}_{(aq)}$$

$$O_2^{2-}{}_{(aq)} + 2H_2O_{(l)} \longrightarrow O_{2(g)} + 4OH^-{}_{(aq)}$$

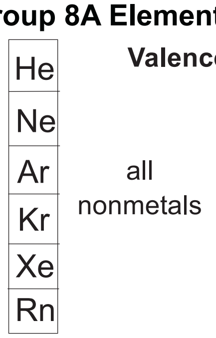
$$4O_2^-{}_{(aq)} + 2H_2O_{(l)} \longrightarrow 3O_{2(g)} + 4OH^-{}_{(aq)}$$

Group 7A Elements: The Halogens

Valence Shell: ns^2np^5 The chemistry of the elements of Group 7A is characterized by 7 valence electrons.

All Halogens are diatomic at standard state conditions: F_2, Cl_2, Br_2, I_2
Very reactive. Never found in elemental form in nature.
Most common oxidation state -1.
High ionization energies (1 electron away from a full octet).

Group 8A Elements: The Noble Gases



Valence Shell: ns^2p^6 The noble gases have a complete outer octet.

Very stable and unreactive
Don't want to lose or gain electrons
Some molecules have been formed with noble gases--typically expanded octets