Groups : Overview

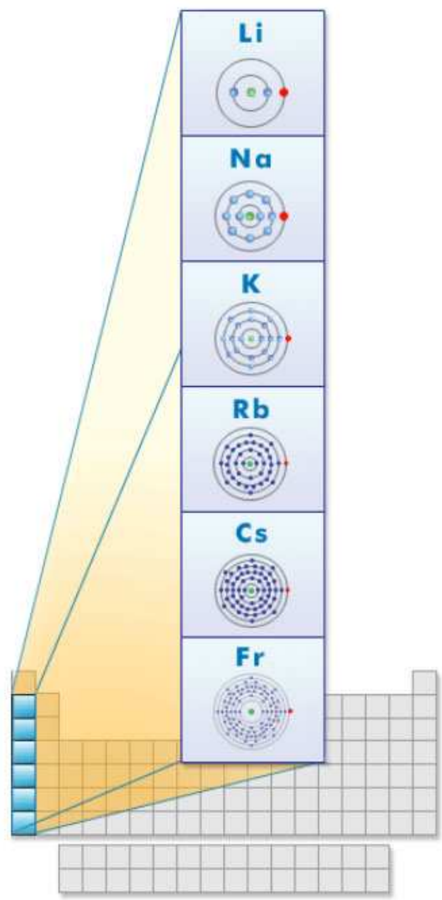
When you look at the periodic table, it is very apparent that the elements have been organized into some kind of order, in rows and columns. The first and most important division within the table is the individual columns, known as Groups or Families. Just as most groups or families tend have some specific characteristics or traits in common (like being tall or having brown eyes), the elements have certain properties that are defined by the group they are in.

The groups are numbered according to several different conventions, but the most commonly accepted method is the IUPAC (International Union of Pure and Applied Chemistry) system, which labels the groups from left to right with numbers 1 through 18. This is the system we will be using here.

Let's take a tour of the different groups one at a time.

ALKALI METALS

About the Group



The first column of the periodic table is the group of elements known as the Group 1 or **alkali metals**. This group includes lithium, sodium, potassium, rubidium, cesium, and francium. By definition, a metal is an element that loses one or more electrons to create a positively charged ion known as a **cation** (pronounced "cat"- "ion"). The alkali metals have only one electron in their outermost energy level. All elements would like to have complete s and p orbitals in their outermost energy levels, an arrangement of eight electrons called an octet. The rule of thumb for creating any type of ion is called the **Octet Rule**. The Octet Rule says that elements lose, gain, or share electrons to form the required octet in their highest remaining energy level.

Chemical Properties

The alkali metals are the most reactive of all of the metals. Adding them to water causes the hydrogen in the water to be released as a gas, and the formation of very strong bases known as hydroxides. The release of hydrogen is also accompanied by a release of energy during the reaction. For example, adding metallic lithium to water will cause strong fizzing and bubbling with a slight increase of heat. Adding metallic sodium to water will cause more rapid production of hydrogen gas. But adding even a small amount of potassium to water will release a large enough amount of energy to cause an explosion and fire as the hydrogen gas is released and ignited.

In the "Real" World

When metals combine with nonmetals they form a class of chemicals known as salts. The common table salt you use every day is a compound of sodium, an alkali metal, and chlorine, a very reactive nonmetal. Other salts are formed when a different metal or nonmetal is used. Salt substitutes are often potassium chloride compounds. The potassium is used instead of sodium to create the compound. This allows people to control the sodium intake in their daily meals.

Notes:

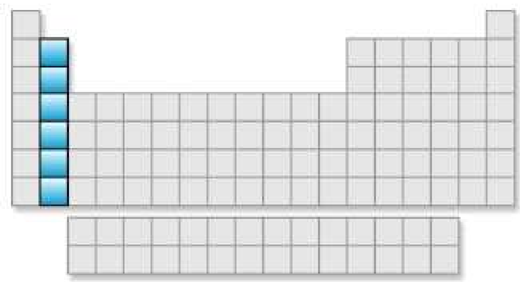
ALKALINE EARTH METALS

About the Group

The second column of elements from the left of the periodic table is known as the Group 2 or **alkaline earth metals**. It consists of beryllium, magnesium, calcium, strontium, barium, and radium. Originally the term "alkaline earths" referred only to the oxides of calcium, strontium, and barium. The definition was later broadened to include the entire Group 2 family of elements. This group commonly loses the two s orbital electrons found in their outermost energy level. The remaining ion then has the desired complete octet of s and p orbital electrons in its outermost energy level.

Chemical Properties

One of the signature properties of this group of elements is that they become increasingly soluble with a decrease in temperature. This is usually true only for gases. Just imagine stirring sugar into a glass of tea. If you want to make really sweet tea, you need to add the sugar before adding the ice. Hot tea will dissolve more sugar in the same volume than cold tea. If the sugar were calcium, more calcium would dissolve into the liquid as you added the ice.



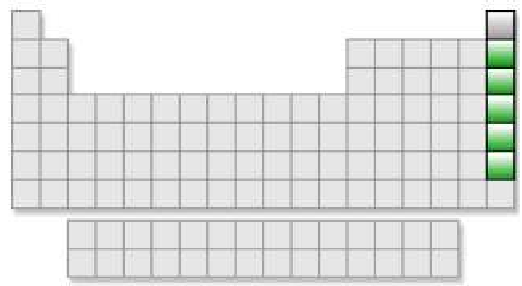
Notes:

NOBLE GASES

About the Group

Let's look at the other side of the periodic table now. The group of elements at the far right of the table (Group 18) is known commonly as the **noble gases**. They are generally chemically inert. This means that they do not react with other elements because they already have the desired eight total s and p electrons in their outermost (highest) energy level. The elements in this group are helium, neon, argon, krypton, xenon, and radon. They are monatomic gases. These gases were not discovered until the last five years of the 1800s. They are extremely rare in nature, and none was known until helium was discovered to exist on the sun. In fact, the name of the element helium was derived from the Greek word Helios, used to refer to the sun.

Chemical Properties



Of the noble gases, only helium and neon are truly inert. The other noble gases will react on a limited scale under very specific conditions. Krypton will form a solid with fluorine, and xenon will form a variety of compounds with oxygen and fluorine.

In the "Real" World

The noble gases are used in industry in arc welding, to dilute the oxygen in deep-sea divers' gas tanks, and to fill light bulbs. Argon is used in arc welding and in common light bulbs, as it does not react with the metal at high temperatures. Helium is used for diluting the pure oxygen in deep-sea diving tanks because the helium has a low solubility in human blood. Helium is also used to inflate the tires of large aircraft, weather balloons, and blimps because it is nonflammable. Neon is used in sign tubing because it glows bright red when electricity is passed through it. Krypton and xenon are used in photographic flash units and in lighthouses, as running an electric current through either element generates a very bright light.

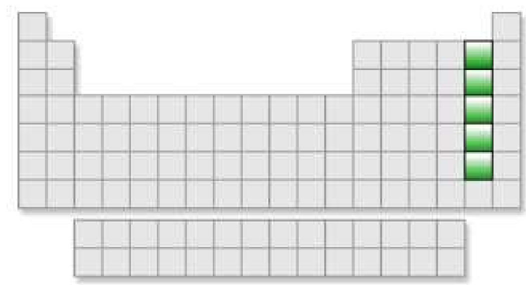
Notes:

HALOGENS

About the Group

Group 17 is a family of elements known as the **halogens**. The word "halogen" means "salt-former." The halogens form salts when they react with a metal. Halogens exist in a variety of states at room temperature. Fluorine and chlorine are gases, bromine is a liquid, and iodine and astatine are solids. All of these elements exist as diatomic molecules in their gaseous state. This means that two atoms bond together to form a molecule of the gas.

Chemical Properties



The elements in this group are all one electron short of having a complete s-p octet in their outer energy level. Any element that accepts electrons to form a complete octet is called a **nonmetal**. The halogens will typically take an electron from a metal or even a weaker nonmetal to complete the desired octet. The ions formed by this transfer of electrons to the nonmetal are negatively charged because they have more electrons than protons. They are called **anions**. Fluorine is the element with the most electronegativity on the entire periodic table. **Electronegativity** is the measure of how strongly an element will attract electrons away from other atoms. Its very high electronegativity makes fluorine the most reactive element.

In the "Real" World

All of the elements of the halogen family are found in common use in everyday life. Fluorine is used in compounds to strengthen the enamel of your teeth against decay. It is also used in acid form to etch glass. Chlorine is used in our drinking water and in swimming pools to inhibit bacterial growth. It is also used in the form of chlorine dioxide to bleach wood pulp in the manufacture of very white paper. We also use chlorine in everyday laundry bleach. Chlorine compounds are used in insecticides, fireworks, and matches.

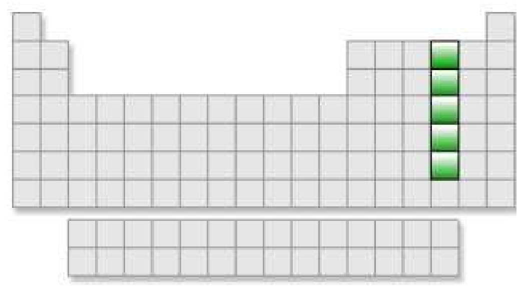
Notes:

OXYGEN FAMILY

About the Group

Group 16 is the **oxygen family**. It consists of the elements oxygen, sulfur, selenium, tellurium, and polonium. Each has six of the desired eight electrons required for the octet in its highest energy level. This means that it takes or accepts two electrons from atoms of other elements to form anions or shares two electrons to form covalent bonds.

Chemical Properties



Oxygen and sulfur are common elements. In fact, oxygen is the most common element (by mass) in the earth's crust. Because oxygen is second in electronegativity only to fluorine, it reacts with almost everything to form compounds here on earth. Selenium has some semimetal characteristics, such as an increase in electrical conductivity when a light is shined on it. Tellurium is a true semimetal, existing in compound with both positive and negative charges. Polonium is an extremely rare radioactive element discovered by Marie Curie and named for her native Poland. This means that the oxygen family is split between nonmetals and semimetals.

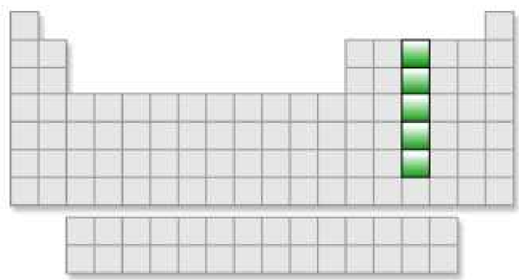
Notes:

NITROGEN FAMILY

About the Group

The Group 15 elements are generally known as the **nitrogen family**. All of the elements of this family have five electrons in their outermost energy level. This group is divided into nonmetals, semimetals, and metals by characteristic. The top two elements, nitrogen and phosphorus, are very definitely nonmetals, forming -3 charge anions. Nitrogen is a diatomic gas and phosphorus is a solid. The elements arsenic, antimony, and bismuth all have some characteristics of semimetals such as brittleness as a free element. Arsenic is the only true semimetal of the three, existing in compounds with both -3 or + 5 charges. Antimony and bismuth can exist with a -3 charge in compound but are more commonly found as metals with a +5 charge because of their size. The pull of the positive protons found in their nucleus is so far from the outer shell (highest energy level) that the outer energy level electrons are more easily stripped off than they are able to attract three more electrons to complete the octet. In fact, bismuth is generally classified as a metal.

Chemical Properties



Nitrogen is used in saltpeter for fertilizer and explosives. It is also useful to create an oxygen-free atmosphere to prevent oxidation or combustion. A common use for liquid nitrogen today is the rapid freezing of food products. We also use liquid nitrogen in medical/surgical applications such as cryotherapy and cryosurgery. Phosphorus is used in compounds such as phosphoric acid, to make synthetic fertilizers, and in detergents. Arsenic and antimony are most commonly found in alloys used for the production of batteries and special types of solder. Bismuth is commonly used for alloys of metals and as a component of cosmetics or medicine used to treat upset stomach (Pepto-Bismol) and eczema.

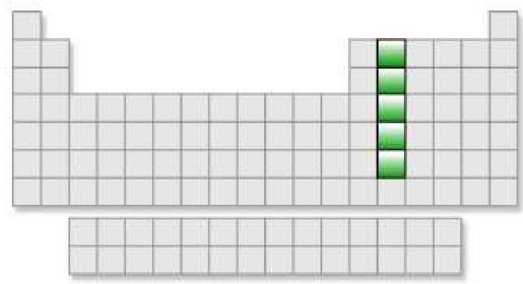
Notes:

CARBON FAMILY

About the Group

Group 14 is the **carbon family**. The five members are carbon, silicon, germanium, tin, and lead. All of these elements have four electrons in their outermost energy level. Of the Group 14 elements, only carbon and silicon form bonds as nonmetals (sharing electrons covalently). Silicon and germanium are semimetals (metalloids), existing in compounds with either +4 or -4 charges. Tin and lead are definitely metals. They always lose electrons due to the distance of their outer shells from the nucleus. They usually form compounds as cations with a +4 charge. All of the elements of this family can form four bonds, the most of any family.

Chemical Properties



The element carbon is the basis of life. It is found in all living material. Silicon is a semiconductor used commonly in computer chips and solar cells. It is also the second most abundant element in the earth's crust. Silicon dioxide, SiO_2, is the major component of glass. Germanium has important semiconductor properties and is used in the computer industry. It is one of the few elements that expand when frozen. Lead has long been used for plumbing and is also used to block radiation. Tin was once used to make cans because it is relatively stable -- unreactive. Aluminum has replaced the more expensive tin today.

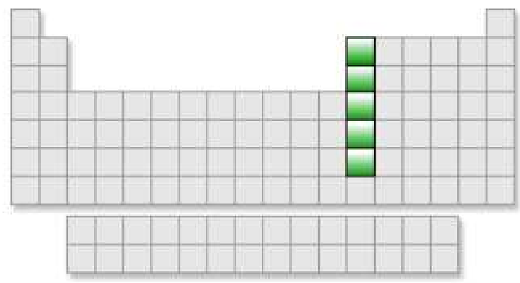
Notes:

BORON FAMILY

About the Group

The last of the p block families we will be looking at is the **boron family** -- Group 13. This group includes the elements boron, aluminum, gallium, indium, and thallium. All five have three electrons in their outer energy level. Only one member of this family is a metalloid -- boron. The others are classified as metals, forming positive ions by giving up their three outermost electrons.

In the "Real" World



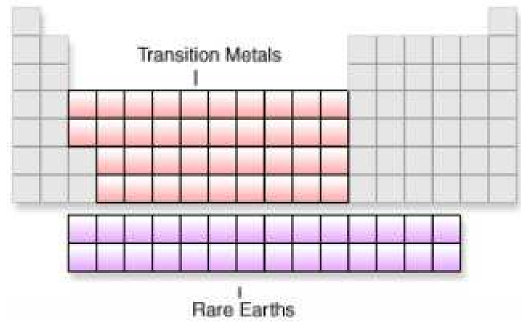
Boron is most commonly found as borax and boric acid, which are used in cleaning compounds. Aluminum is the third most common element in the earth's crust. It is used as a coating agent, to prevent oxidation. It is an excellent conductor of electricity and heat and can be found in many cooking utensils. Gallium is important today in the production of gallium arsenide LEDs and laser diodes. Indium is a very soft metal that can actually be wiped onto other metals as an anticorrosion agent. It also has the peculiar quality of squealing when bent. Finally, thallium is quite toxic and is sometimes used in rat poisons. It has also been used in glass to make special infrared filters.

Notes:

TRANSITION METALS AND RARE EARTHS

About the Groups

The remaining elements of the periodic table can be lumped into two major divisions, the **transition metals** (Groups 3-12) and the **rare earths** (which can be further broken down into the actinides and lanthanides). Each group in the transition metals has complete s and p orbitals with incomplete d orbitals. The elements tend to want the most stable configuration; for example, one electron in each orbital instead of a complete s orbital and four d orbitals with one electron each. This leads to some unique characteristics.



Chemical Properties

The transition elements often act as catalysts in reactions and are often colorful in compounds.

In the "Real" World

Rare earths make the strongest magnets.

Notes:

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http://www.learner.org/interactives/periodic/groups.html

Periodic Table of the Elements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
**	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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