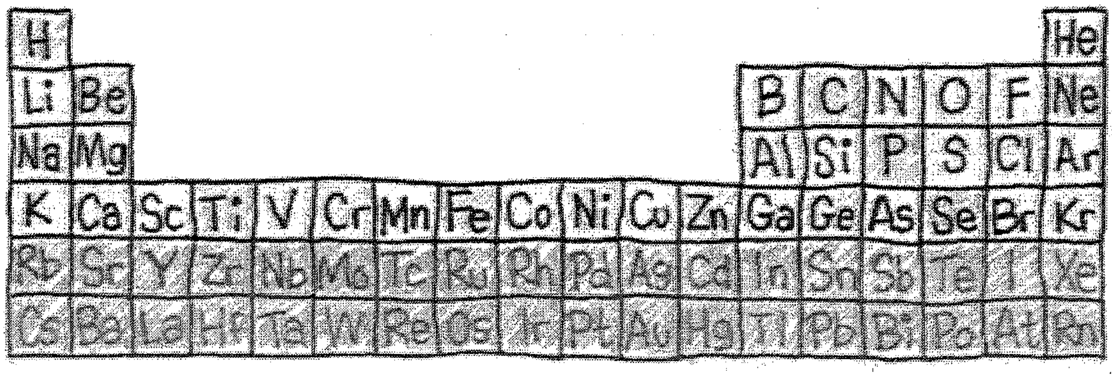
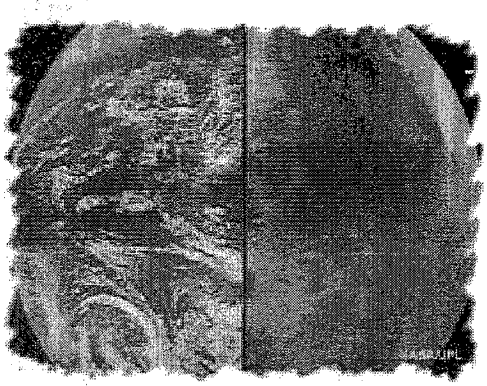
Periodic Table and the Elements



Now we're getting to the heart and soul of the way your universe works. **Elements** are the building blocks of all matter. We talked about **quarks** in the atoms section. They are smaller than the atoms of an element, but only when they group with other quarks do they form atoms that have recognizable traits. Some quarks combine to make an oxygen (O) atom. Other quarks can combine to form a nitrogen (N) atom. It's the atoms that are different and unique, even though they are made of the same pieces.

The Same Everywhere



IRON ATOMS ON EARTH AND MARS ARE EXACTLY THE SAME

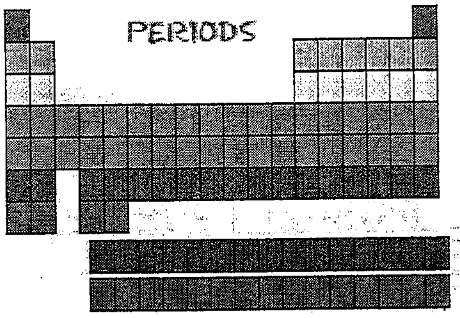
As far as we know, there are only so many basic elements. Up to this point in time we have discovered/created over 100. While there may be more out there to discover, the basic elements remain the same. Iron (Fe) atoms found on Earth are identical to iron atoms found on meteorites. The iron atoms on Mars that make the soil red are the same too.

The point is... With the tools you learn here, you can explore and understand the universe. You will never stop discovering new reactions and compounds, but the elements will remain the same.

Elements as Building Blocks

As you probably saw, the **periodic table** is organized like a big grid. The **elements** are placed in specific places because of the way they look and act. If you have ever looked at a grid, you know that there are rows (left to right) and columns (up and down). The periodic table has rows and columns, too, and they each mean something different.

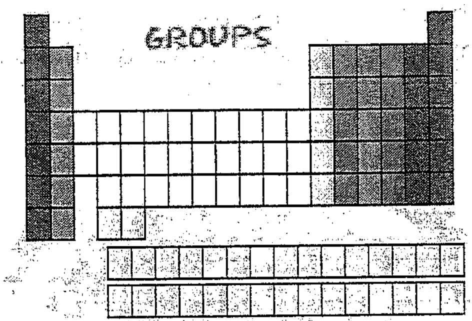
You've got Your Periods...



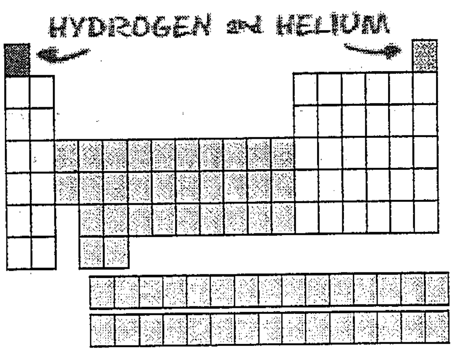
Even though they skip some squares in between, all of the rows go left to right. When you look at a periodic table, each of the rows is considered to be a different **period** (Get it? Like PERIODic table.). In the periodic table, elements have something in common if they are in the same row. All of the elements in a period have the same number of atomic orbitals. Every element in the top row (the first period) has one orbital for its electrons. All of the elements in the second row (the second period) have two orbitals for their electrons. It goes down the periodic table like that. At this time, the maximum number of electron orbitals or electron shells for any element is seven.

...and Your Groups

Now you know about periods. The periodic table has a special name for its columns, too. When a column goes from top to bottom, it's called a **group**. The elements in a group have the same number of electrons in their outer orbital. Every element in the first column (group one) has one electron in its outer shell. Every element on the second column (group two) has two electrons in the outer shell. As you keep counting the columns, you'll know how many electrons are in the outer shell. There are some exceptions to the order when you look at the transition elements, but you get the general idea.



Two at the Top

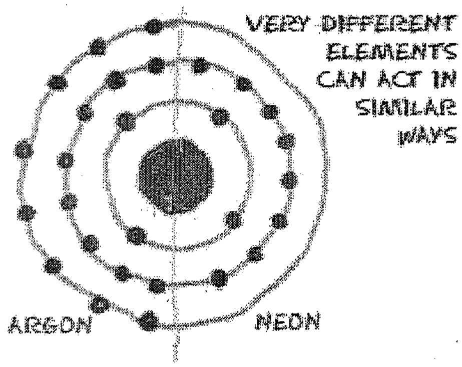


Hydrogen (H) and helium (He) are special elements. Hydrogen can have the talents and electrons of two groups, one and seven. To scientists, hydrogen is sometimes missing an electron, and sometimes it has an extra. Helium is different from all of the other elements. It can only have two electrons in its outer shell. Even though it only has two, it is still grouped with elements that have eight (inert gases).

The elements in the center section are called transition elements. They have special electron rules.

FAMILIES STICK TOGETHER

We just covered the columns and rows of the periodic table. There are also other, less specific, groups of elements. These groups are all over the table. Scientists group these **families** of elements by their chemical properties. Each family reacts a different way with the outside world. Metals behave differently than gases and there are even different types of metals. Some don't react, others are very reactive, and some are metallic.



Usually, the columns of the periodic table are used to define families. The inert gases are all located in the far right column of the table. That column is labeled Group Zero. The other possibility that can happen are elements in a series. Good examples of a series of elements in the same family are the transition metals.

The thing to remember is... A family of elements can be found in several ways. You need to run tests and study the elements to determine their properties. Only after that testing, can you determine what family an element belongs in.

EXAMPLES OF FAMILIES

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Halogen Gases
- Inert Gases (Noble Gases)

EXAMPLES OF PHYSICAL PROPERTIES

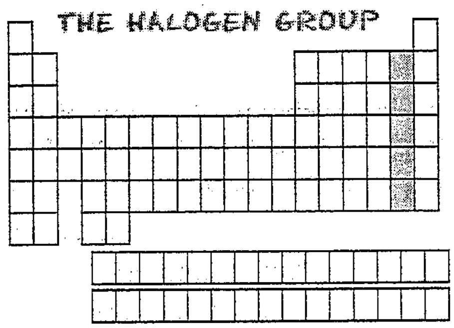
- Density
- Boiling Point
- Melting Point
- Conductivity
- Heat Capacity

EXAMPLES OF CHEMICAL PROPERTIES

- Valence
- Reactivity
- Radioactivity

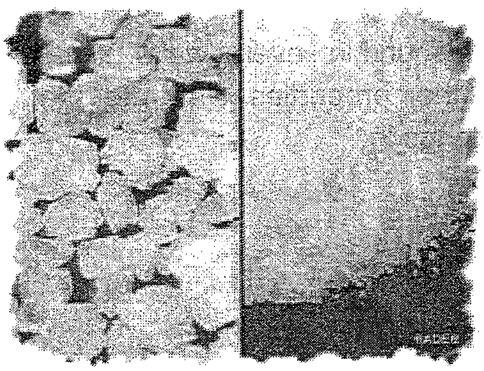
HALOGENS ON THE RIGHT

In the second column from the right side of the periodic table, you will find Group Seventeen (Group XVII). This column is the home of the **halogen** family of elements. Who is in this family? The elements included are Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), and Astatine (At).



WHAT MAKES THEM SIMILAR?

When you look at our descriptions of the elements fluorine (F) and chlorine (Cl) you will see that they both have seven electrons in their outer shell. That seven-electron idea applies to all of the halogens. They are all just one electron shy of having full shells. Because they are so close to being happy, they have the trait of combining with many different elements. You will often find them bonding with metals and elements from Group One of the periodic table.



POTASSIUM IODIDE (L) AND SODIUM CHLORIDE (R) ARE BOTH HALIDES.

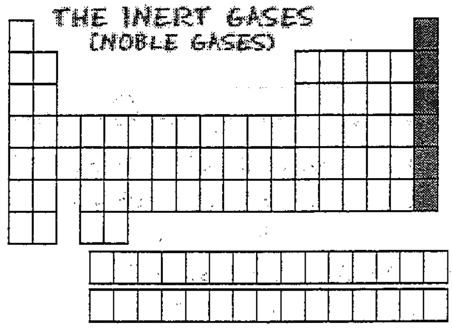
We've just told you how **reactive** they are. Not all halogens react with the same intensity. Fluorine is actually the most reactive and combines all of the time. As you move down the column, reactivity decreases. As you learn more about the table, you will find this pattern true for other families.

THEN WHAT IS A HALIDE?

The elements we are talking about in this section are called halogens. When a halogen combines with another element, the resulting compound is called a **halide**. One of the best examples of a halide is sodium chloride (NaCl). Don't think that the halogens always make ionic compounds. Many halides of the world are made with covalent compounds.

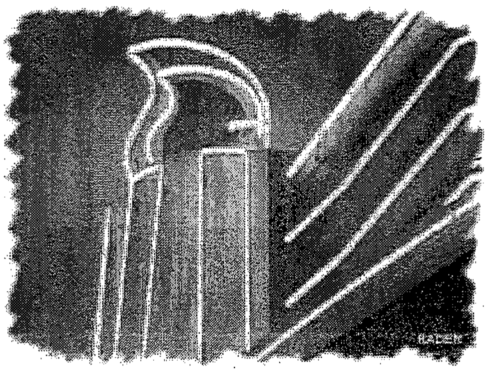
THE NOBLE INERT GASES

We love the inert gases. Some scientists used to call them the **noble gases**. These gases are another family of elements, and all of them are located in the far right column of the periodic table. For all of you budding chemists, the far right is also known as Group Zero (Group 0) or Group Eighteen (Group XVIII). This family has the happiest elements of all.



WHY ARE THEY HAPPY?

Using the **Bohr** description of electron shells, happy atoms have full shells. All of the inert gases have full outer shells with eight electrons. Oh wait! That's not totally correct. At the top of the inert gases is little helium (He) with a shell that is full with two electrons. The fact that their outer shells are full means they are quite happy not reacting with other elements. In fact, they rarely combine with other elements. That nonreactivity is why they are called inert.



NEON IS USED IN MANY STREET SIGNS.

WHO'S IN THE FAMILY?

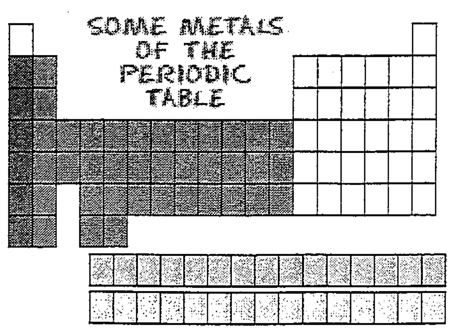
All of the elements in Group Zero are inert gases. The list includes Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe), and Radon (Rn). Don't think that because these elements don't like to react, we don't use them. You will find inert gases all over our world. Neon is used in advertising signs. Argon is used in light bulbs. Helium is used to cool things and in balloons. Xenon is used in headlights for new cars. When you move down the periodic table, as the atomic numbers increase, the elements become rarer. They are not just rare in nature but rare as useful elements, too.

BUT WAIT, THEY DO BOND!

Some do. As of about 40 years ago, scientists have been able to make some compounds with inert gases. Some have been used in compounds to make explosives and other just form compounds in a lab. The thing to remember is that they were forced. When going about their natural lives, you will never (never say never because there may be an exception) find the inert gases bonded with other elements.

METAL BASICS

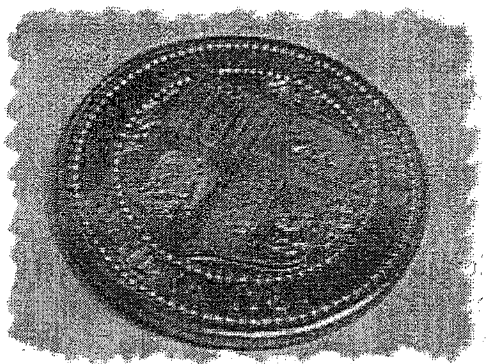
We wanted to give you a big overview of **metals** before we talk about details in other tutorials. Almost



75% of all elements are classified as metals. They are not all like silver (Ag), gold (Au), or platinum (Pt). Those are the very cool and shiny ones. There are other metals like potassium (K) and iridium (Ir) that you might not think about right away.

MANY KINDS OF METALS

How many kinds of metals are there? So many. Don't even try to memorize them all. Just remember the ones you might need in class. Here's a quick list: Actinide Metals, Lanthanide Metals, Alkali Metals, Alkaline-Earth Metals, Noble Metals, Rare Metals, Rare-Earth Metals, and Transition Metals. Lucky for you the periodic table is excellent at organizing elements, and you will find each of these groups in specific areas of the periodic table.



BRONZE WAS ONE OF THE FIRST ALLOYS CRATED BY HUMANS.

HOW DO YOU IDENTIFY A METAL?

What are the characteristics of metals? We've got four traits that will help you identify whether an element is a metal or not.

Conduction: Metals are good at conducting electricity. Silver (Ag) and copper (Cu) are some of the most efficient metals and are often used in electronics.

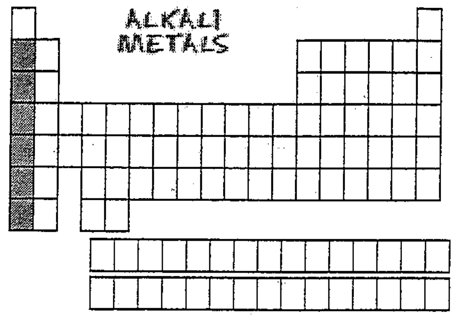
Reactivity: Metals are very reactive, some more than others, but most form compounds with other elements quite easily. Sodium (Na) and potassium (K) are some of the most reactive metals.

Chemical: A little complex here. Metals usually make positive ions when the compounds are dissolved in solution. Also, their metallic oxides make hydroxides (bases) (OH-) and not acids when in solution. Think about this example. Sodium chloride (NaCl), when dissolved in water, breaks apart into sodium (Na+) and chlorine (Cl-). See that sodium is the positive ion? Sodium is the metal. It works that way for other metals. Potassium chlorine (KCl) works the same way.

Alloys: Metals are easily combined. Mixtures of many elements are called alloys. Examples of alloys are steel and bronze.

ALKALI METALS TO THE LEFT

Let's start on the left side of the periodic table. When looking for families, the first one you will find is the **alkali metal** family of elements. They are also known as the alkaline metals. You should remember that there is a separate group called the alkaline earth metals in Group Two. They are a very different family even though they have a similar name. That far left column is Group One (Group I). When we talk about the groups of the periodic table, scientists use Roman numerals when they write them out.



A FAMILY PORTRAIT

Who's in the family? Starting at the top we find hydrogen (H). But wait. That element is NOT in the family. When we told you about families, we said that they were groups of elements that react in similar ways. Hydrogen is a very special element of the periodic table and doesn't belong to any family. While hydrogen sits in Group I, it is NOT an alkali metal.

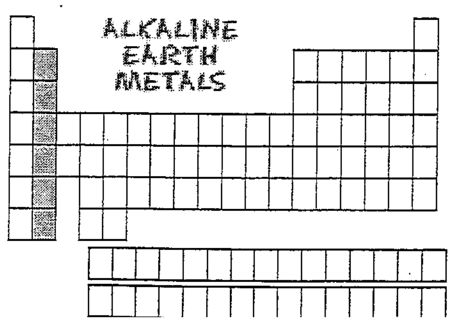
FAMILY BONDING

Now that we've covered that exception, the members of the family include: Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Cesium (Cs) and Francium (Fr). As with all families, these elements share traits. They are very **reactive**. Why? They all have one electron in their outer shell. That's one electron away from being happy (full shells). When you are that close to having a full shell, you want to bond with other elements and lose that electron. An increased desire to bond means you are more reactive. In fact, when you put some of these pure elements in water, they will cause huge explosions.

The alkali metals are also metals. That seems obvious from the name. Often, in chemistry, characteristics are assigned by the way elements look. You will find that the alkali group is shiny and light in weight. Their light weight and physical properties separate them from other metals. Alkali metals are not the type of metals you would use for coins or houses.

HEADING TO GROUP TWO

So we just covered the alkali metals in Group I. You will find the **alkaline earth metals** right next door in Group II. This is the second most **reactive** family of



elements in the periodic table. Did you know why they are called alkaline? When these compounds are mixed in solutions, they are likely to form solutions with a pH greater than 7. Those pH levels are defined as 'basic' or 'alkaline' solutions.

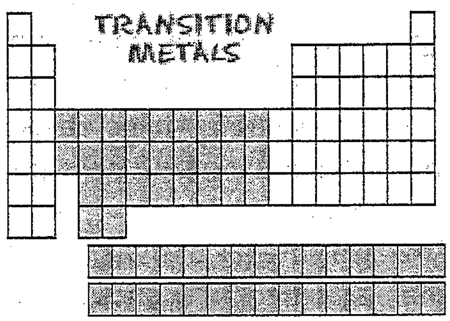
A FAMILY PORTRAIT

Who's in the family? The members of the alkaline earth metals include: beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba) and radium (Ra). As with all families, these elements share traits. While not as reactive as the alkali metals, this family knows how to make bonds very easily. Each of them has two electrons in their outer shells. They are ready to give up those two electrons in **electrovalent bonds**. Sometimes you will see them with two halogen atoms (BeF_2) and sometimes they might form a double bond (CaO). It's all about giving up those electrons to have a full outer shell.

As you get to the bottom of the list, you will find the radioactive radium (Ra). While radium is not found around your house anymore, it used to be used in glow-in-the-dark paints. The other elements are found in many items including fireworks, batteries, flashbulbs, and special alloys. The lighter alkaline earth metals such as magnesium and calcium are very important in animal and plant **physiology**. You all know that calcium helps build your bones.

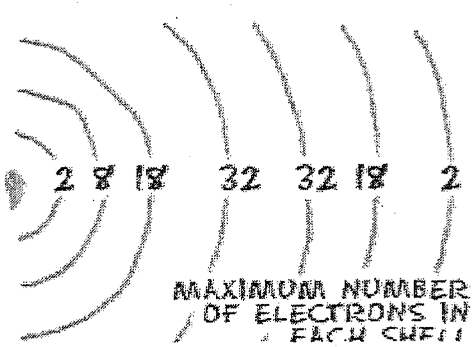
TRANSITIONING

Lets start off by telling you that there are a lot of elements that are considered **transition metals**. Which metals are the transition metals?
21 (Scandium) through 29 (Copper)
39 (Yttrium) through 47 (Silver)
57 (Lanthanum) through 79 (Gold)
89 (Actinium) and all higher numbers.



WHAT MAKES THEM SO SPECIAL?

It all has to do with their shells/**orbitals**. In **CHEM4KIDS** we try to stick to the first 18 elements because they are easy to explain. Transition metals are good examples of advanced shell ideas. They have a lot of electrons and distribute them in different ways.



Transition metals are able to put more than eight **electrons** in the shell that is one in from the outermost shell. Think about argon (Ar). It has 18 electrons set up in a 2-8-8 order. Scandium is only 3

spots away with 21 electrons, but it has a configuration of 2-8-9-2. Wow! This is where it starts. This is the point in the periodic table where you can place more than 8 electrons in a shell.

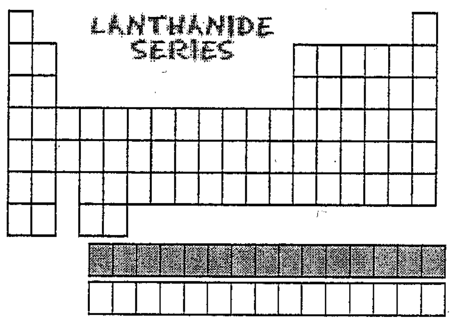
The transition metals are able to put up to 32 electrons in their second to last shell. Something like gold (Au) has an organization of 2-8-18-32-18-1. Of course, there are still some rules. No shell can have more than 32 electrons. It's usually 18 or 32 for the maximum number of electrons.

ONE MORE THING

Most elements can only use electrons from their outer orbital to bond with other elements. Transition metals can use the two outermost shells/orbitals to bond with other elements. It's a chemical trait that allows them to bond with many elements in a variety of shapes. Why can they do that?

As you learn more, you will discover that most transition elements actually have two shells that are not happy. Whenever you have a shell that is not happy, its electrons can bond with other elements. Example: Molybdenum (Mo) with 42 electrons. The configuration is 2-8-18-13-1. The shells with 13 and 1 are not happy. Those two orbitals can use the electrons to bond with other atoms.

LANTHANIDE SERIES OF METALS



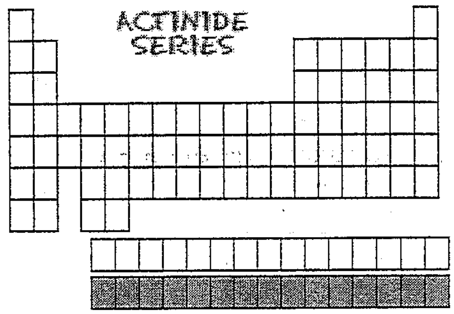
When you look at the periodic table you will see two rows that kind of sit off to the bottom. One of those rows is called the Lanthanide series. There are a bunch of names that you may hear that describe these 15 elements. Some say Lanthanide, some say **rare-earth** and some say **inner-transition** elements. No matter what you choose everyone will know what you mean if you say Lanthanide.

MEET THE FAMILY

Fifteen elements that start with lanthanum (La) at atomic number 57 and finishing up with lutetium (Lu) at number 71. It's doubtful your teachers will ever ask you to remember all of the elements in the series, just remember lanthanum.

ACTINIDE SERIES OF METALS

There are two rows under the table. The Lanthanide and Actinide series. The Lanthanide series can be found naturally on Earth. Only one element in the series is **radioactive**. The Actinide series is much different. They are all radioactive and some are not found in nature. Some of the elements with higher atomic numbers have only been made in labs. There are special laboratories across the world that specialize in experimenting on elements. Some of these **particle accelerators** have pounded atomic particles into elements with lower atomic numbers. The buildup of additional parts creates short-lived elements.



MEET THE FAMILY

Fifteen elements that start with actinium (Ac) at atomic number 89 and finishing up with lawrencium (Lr) at number 103. It's doubtful your teachers will ever ask you to remember all of the elements in the series, just remember actinium.