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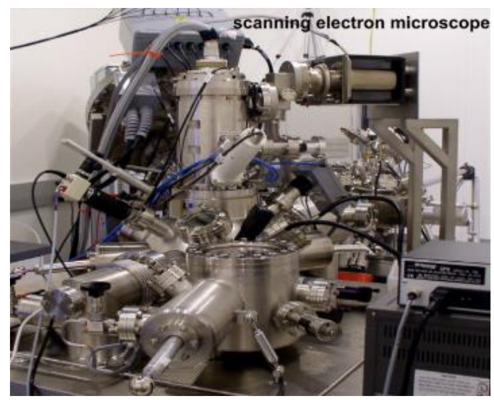
Fascinating Education Script
Fascinating Chemistry Lessons

Lesson 1: The Structure of the Atom

Slide 1: Introduction Slide

Slide 2: Everything is made of atoms

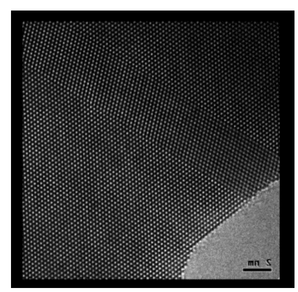
Welcome, everyone. My name is Sheldon Margulies. What we're going to do today is explore how the world works on a molecular level.



One of the hardest concepts for young people to believe is that all things, even things that feel smooth and look smooth like this piece of coal, are made up of separate individual bits, called atoms. Almost all the atoms making up this piece of coal are atoms of carbon.

Atoms are far too small to see or feel, which is why to us, the surface of this piece of coal looks smooth and feels smooth.

Atoms are so small we can barely even get a glimpse of them. The closest we can get to atoms is through this high-powered scanning electron microscope, which uses electricity instead of light to see into the molecular world.

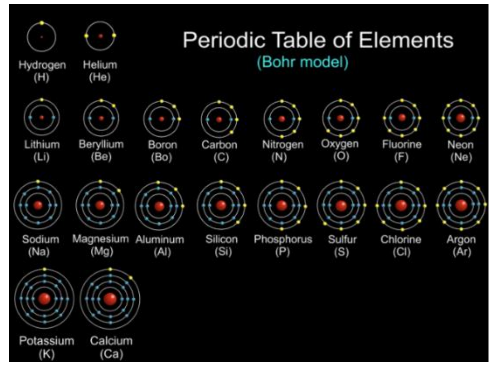


All the white dots are atoms. Notice that they're all completely separate from each other. Why should that be? To answer that, we need to understand the structure of atoms.

Slide 3: The first 20 elements of the periodic table

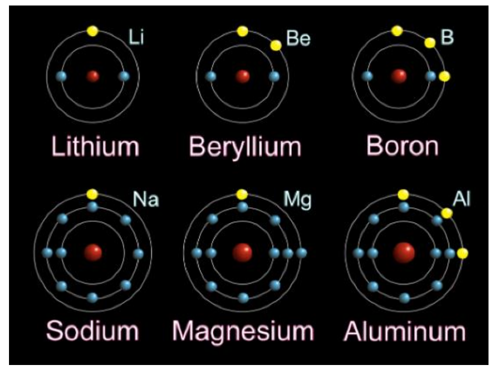
The atoms of carbon we saw through the scanning electron microscope are only one type of atom. There are over a hundred different types of atoms in the world which are listed in a chart called "The Periodic Table of Elements." It's called a Periodic Table of Elements because each element contains only one type of atom.

The first 20 elements in the periodic table are listed here: hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon, sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chlorine, argon, potassium, and calcium.



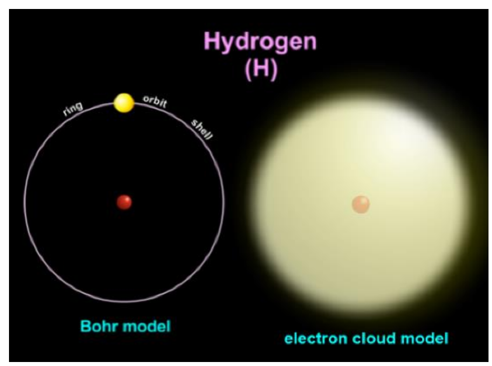
All the atoms depicted here in the periodic table look similar in that in the center of every atom is a nucleus with tiny electrons circling around the nucleus. The rings you see are not real. They're only there to indicate the path that electrons take as they circle the nucleus.

Two things make one atom different from another atom. The first thing is the size of the nucleus in the center of every atom. Hydrogen in the upper left has the smallest nucleus and each element after hydrogen has a slightly larger nucleus.



The second thing that makes the atoms of one element differ from the atoms of every other element is the number of electrons circling around the nucleus. Hydrogen has only one electron and each element after that has one more electron.

How electrons circle the nucleus will be explained in more detail later, but for now we'll depict electrons as circling around the nucleus like a planet around our sun. Niels Bohr, a famous Danish physicist, created this model of the atom about a hundred years ago, so it's called the "Bohr" model of the atom. In the Bohr model electrons circle the nucleus in rings or orbits. The Bohr model is very useful because it simplifies the structure of the atom.

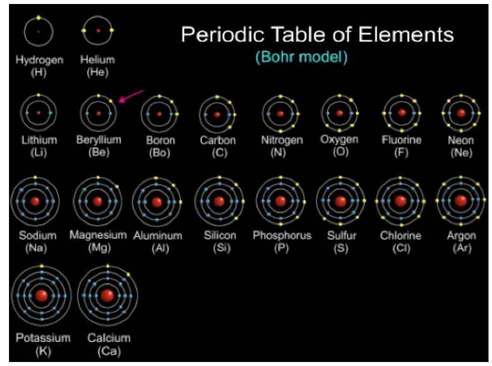


In fact, though, electrons don't move about the nucleus in a circle. They move about the nucleus in various-shaped clouds, depending on how much energy the electron has. The Bohr model acknowledges this fact by referring to rings or orbits as their three-dimensional counterpart -- shells. The terms rings, orbits, and shells are used interchangeably, so don't be confused if sometimes I refer to a ring as an orbit or a shell. They all mean the same thing.

Slide 4: Adding electrons to the elements

So, let's look at the first 20 elements in the periodic table in a little more detail. The simplest atom is the hydrogen atom with only a single electron. Adding an electron to hydrogen gives us a new element, helium.

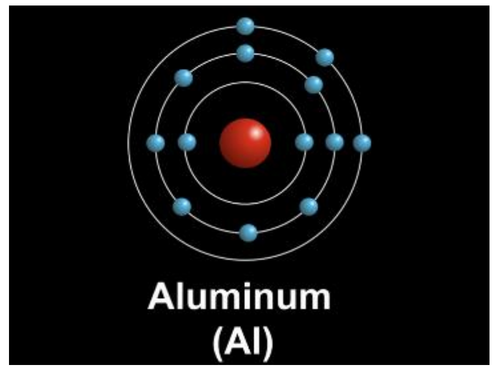
If I want to add a third electron, there's not enough room in that small orbit, or ring, so the third electron has to orbit the nucleus in a larger ring, in Ring 2. The element with three electrons around its nucleus is lithium.



The next atom is beryllium with four electrons, two electrons in Ring 1 and two in Ring 2.

Ring 2 has room for eight electrons. So, if we want to add another electron to beryllium, we just put another electron into Ring 2 and call that atom with five electrons "boron." Boron has two electrons in Ring 1 and three in Ring 2.

With each additional electron, we get a new element: carbon, nitrogen, oxygen, fluorine, and finally neon.



Neon's Ring 2 is now filled with eight electrons. The next electron has to go into a new, larger ring, Ring 3, to form the element, sodium.

Ring 3 can also handle eight electrons. After sodium, each new electron makes magnesium, aluminum, silicon, phosphorus, sulfur, chlorine, and finally argon.

After that, the next electron has to go into Ring 4 as the element potassium and then calcium.

I'm sure you already have some familiarity with these elements. If you would like a brief snapshot of these elements, click on "familiarize yourself with the elements" at the lower right.

Slide 5: Electrons

Each electron has a negative electrical charge on it. Negative electrical charges repel each other, so two electrons approaching each other will veer off, away from each other.

What do you predict would happen if I were somehow able to remove the electrons from this aluminum atom and put them on your body?

First, I need a machine that can remove electrons off an atom. That machine is called a van der Graaf generator, which was invented in 1931. When the van der Graaf generator is turned on, a belt inside the machine strips electrons off atoms and delivers them to the dome up top. The dome becomes electrically negative and if you then touch the dome, the electrons will travel through your body.

This girl is touching the globe and the electrons are flowing into her body, right onto her hair. Why does her hair stand on end?

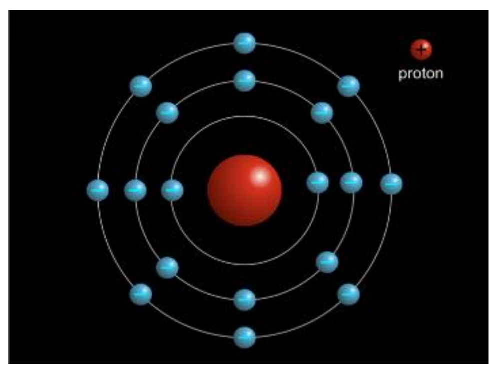
With extra electrons on each strand of hair, each strand of hair is now electrically negative and repelling every other strand of electrically negative hair.

Do you understand now why the carbon atoms viewed under the scanning electron microscope were separated from each other? The electrons around each atom prevent the neighboring carbon atoms from getting too close.

So even though things feel smooth, they're really not. There are tiny spaces between atoms that are too small for us to see or feel, but those tiny electrons around each nucleus repel each other with so much force that atoms never really touch each other.

So when you rest this baseball on the stool, the baseball doesn't actually touch the stool, because the electrons around the atoms in the stool repel the electrons in the approaching baseball with enough force to keep the baseball suspended a smidgen above the stool.

Slide 6: The nucleus

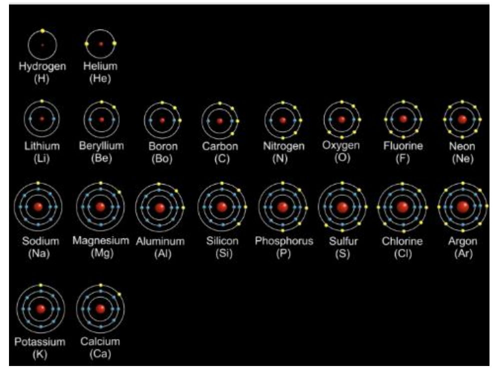


If electrons repel each other, why are they circling close together around the nucleus of an atom? Why don't they repel each other away from the nucleus?

Because negative is attracted to positive, and the nucleus of an atom is electrically positive.

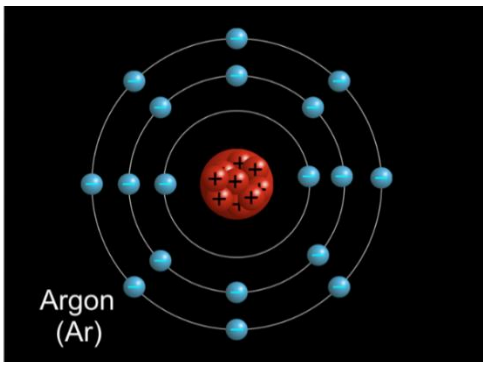
What makes the nucleus positive is a tiny round structure inside the nucleus called a "proton." As small as a proton is, it's still about 2000 times heavier than a wispy little electron.

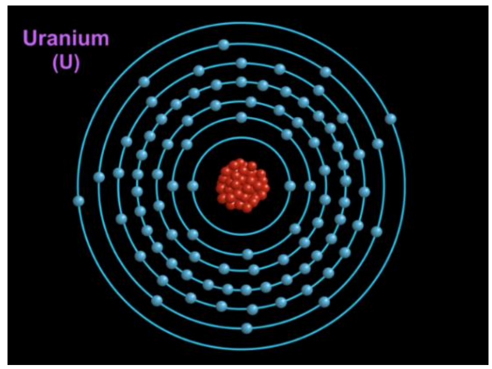
For every electron circling around the nucleus of an atom, there's a proton inside the nucleus keeping the electron close by. So, with only one electron, hydrogen must have only one proton. As each element adds a proton to the nucleus and an electron around the nucleus, the atoms slowly enlarge.



By the time we get over to argon with 18 electrons, there are 18 protons inside the nucleus.

Uranium is huge. It has 96 electrons, so it must have 96 protons in its nucleus.



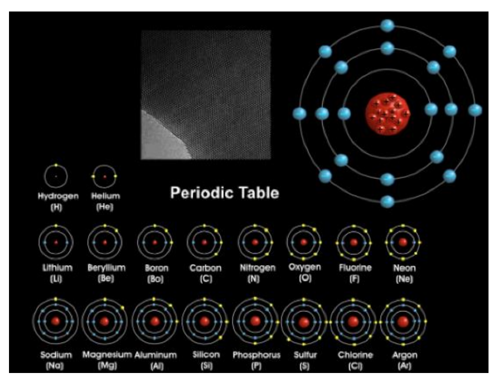


Slide 7: Catching our breath

Let's stop for a second and catch our breath.

We've learned that everything in the world is digital, and the individual bits are called "atoms. "

There's about a hundred different types of atoms, representing 100 different elements, all listed in the periodic table. All 100 atoms look similar -- a central nucleus made up of positively charged protons circled by electrically negative electrons.

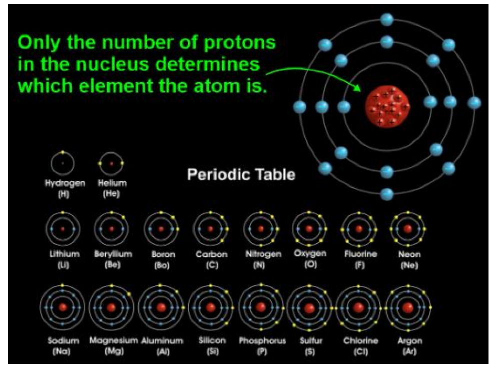


The negative electrons would normally repel each other far away, except they're all attracted to the positively charged protons in the nucleus, and thus remain fairly close together circling the nucleus.

The smallest atom is hydrogen with 1 proton in the nucleus and 1 electron circling the proton.

Each larger atom in the periodic table represents the addition of a proton and an electron.

Slide 8: Defining an element

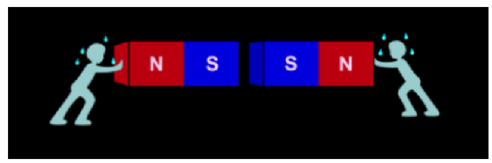


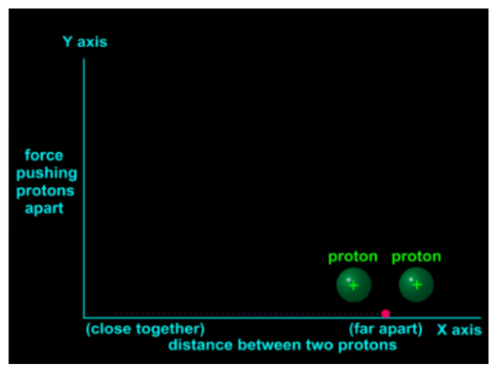
We saw from the periodic table that the atoms in each element differ from each other by both the number of protons in their nucleus and the number of electrons circling the nucleus. We also saw that we could remove electrons from atoms with a van der Graaf generator. Does removing an electron from an atom change that atom from one element to another?

No, because what determines which element an atom belongs to is the number of protons in its nucleus, and that doesn't change unless we bombard the nucleus in a cyclotron, a giant magnet that accelerates protons and other charged particles and busts the nucleus apart; or if nature causes the nucleus to erupt in some way, which we'll come to in a later lesson.

The take-home message is that each element is defined by the number of protons in its nucleus, not by the number of electrons circling the nucleus.

Slide 9: Proton repulsion





Everything makes sense so far except for one thing: don't protons, like electrons, also repel each other? And doesn't the repulsive force between protons increase the closer they move together, just like the two south poles of a magnet? Why aren't all the protons in the nucleus exploding apart?

To answer that, I need to show you a graph of how fast, and how high, the repulsive force gets between two protons when two protons are pushed together.

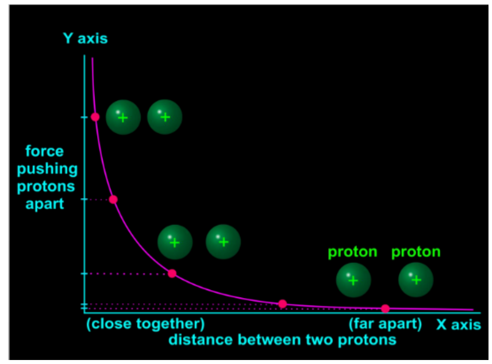
A graph begins with two lines perpendicular to each other. Each line is called an axis.

The horizontal axis is the X axis, and the vertical one, the Y axis. The X and Y axes can represent whatever we like. In this example, we'll make the X axis represent the distance between two protons, so the further to the right we go on the X axis, the further apart the protons are from each other.

The Y axis will be the force pushing the two protons apart.

Let's start with two protons far apart. That means we have to begin far over to the right along the X axis.

The electrical force pushing the two protons apart is not very great when the two protons are far apart, so the distance up the Y axis won't be very high. This red dot says that when two protons are far apart, the electrical force pushing them apart is small.



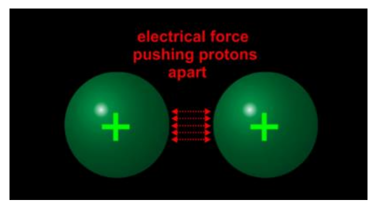
If the electrical force increases as we push the two protons closer together, where would the red dot go if we push the two protons closer together? Sure, higher along the Y axis.

As we continue to push the protons together, the electrical force pushing them apart keeps getting higher and higher.

If we try to push the two protons very close together, the electrical force pushing them apart simply becomes too great to keep the protons bunched together.

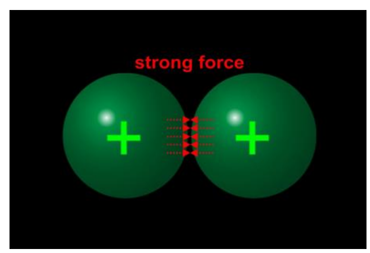
So, let's pretend you're designing the atom. How would you overcome this extremely large repulsive force between protons in the nucleus?

Slide 10: Creating the strong force



One thing you could do is create a new force that suddenly pulls the protons together when they get very close to each other.

This new force would have to be stronger than the electrical force pushing them apart, and here's the key, this new force would only work over a very short distance when the protons are practically touching each other.



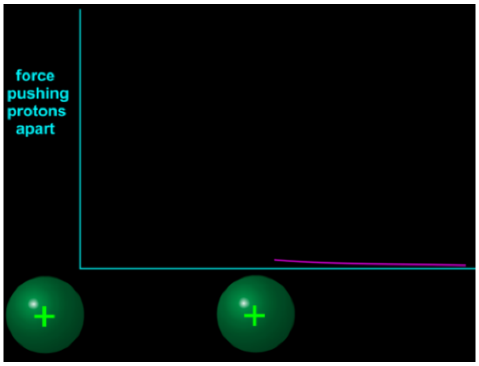
The name for the new force that's stronger than the electrical force pushing the protons apart is -- don't be surprised – the "strong force."

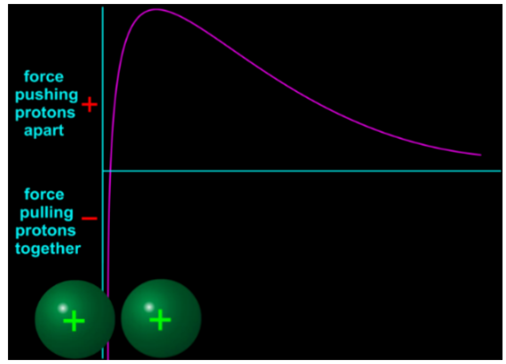
How does the strong force change the shape of our graph?

Without the strong force, the repulsive electrical force between protons rises dramatically as protons approach each other.

But with the strong force, once the protons get right next to each other, the strong force takes over and pulls the protons together.

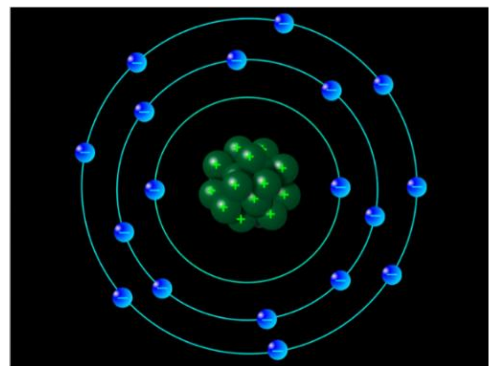
We see the strong force taking over when the graph starts plunging downward. The strong force becomes greater that the electrical force when the graph line plunges below the X axis.





Protons, then, have both an electrical repulsive force and, when the two protons get very close to each other, a strong attractive force.

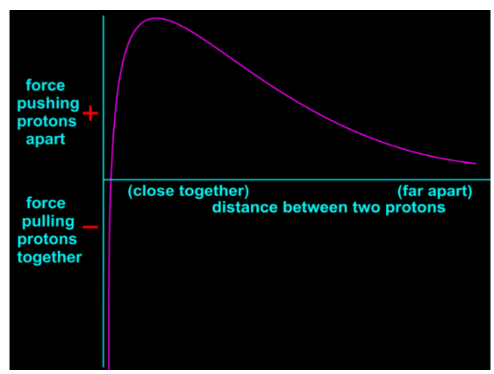
Slide 11: Neutrons



Do you see any other way to help protons overcome their mutual repulsion and keep them close together in the nucleus?

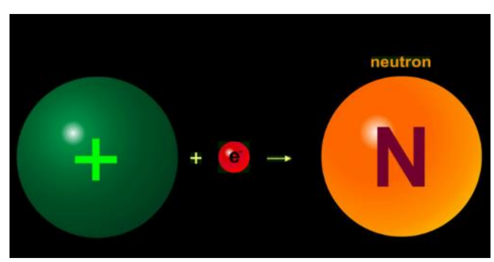
How about if we try to reduce the strength of the electrical force pushing protons apart? How could we do that?

We know from our graph that the further apart protons are, the lower the electrical force pushing them apart. So maybe we could keep the protons together better by moving the protons apart slightly and reducing the electrical force pushing them apart.

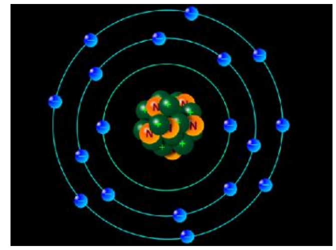


The only problem with this approach is that moving protons apart drastically reduces the strength of the strong force, which only works when the protons are practically touching each other. Now what?

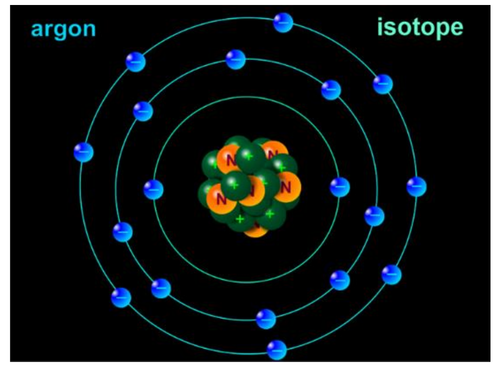
How about if we move the protons slightly apart with something that also has a strong force? Like what?



Protons have a strong force, so let's try combining a proton with an electron. We'll call this new structure a neutron since a proton and an electron, combined, are electrically neutral, neither positive nor negative. Being electrically neutral, a neutron can wiggle in between two protons without exerting a positive electrical force on either proton and causing the whole nucleus to split apart. With the protons nudged apart, their electrical repulsion is less, and because the neutron was made from a proton and an electron, the neutron has a strong force, Neutrons, then, can push the protons apart slightly without weakening the strong force.



Slide 12: Isotopes

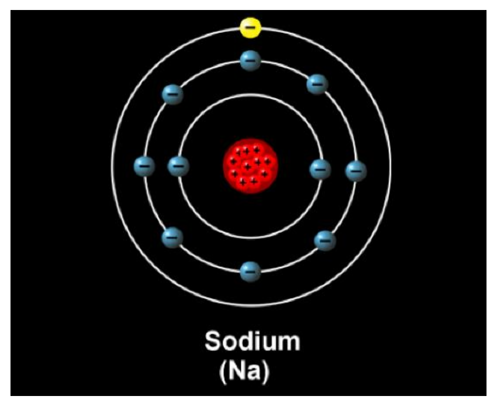


You might expect every element to have the same number of neutrons in its nucleus, but that's not what happens. Different atoms of the same element may have different numbers of neutrons in their nucleus. No matter how many neutrons a nucleus has, though, the atom remains the same element, because adding neutrons to the nucleus does not change the number or protons in the nucleus, and it's the number of protons in the nucleus that determines the element.

Atoms with different numbers of neutrons in the nucleus are called "isotopes" of that element. Most, but not all, elements in the periodic table have isotopes. The element argon, for example, has over 20 different isotopes.

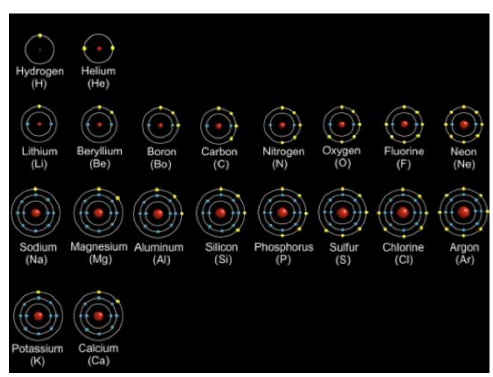
Different isotopes of an element weigh slightly more or less than other isotopes of that element but, chemically, all isotopes of an element behave pretty much the same.

Slide 13: Catching our breath



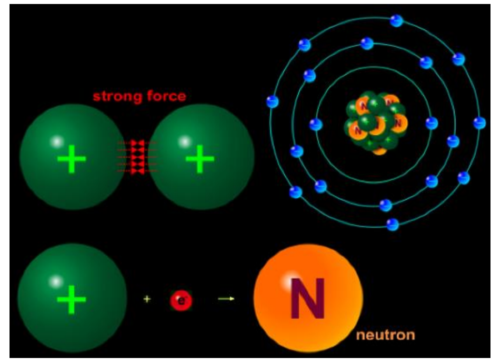
Time to stop and catch our breath.

What we've learned about electrons is that, being electrically negative, they repel each other, but stay together around the nucleus because of their attraction to the positively charged protons in the nucleus.



What we've learned about protons is that the number of protons in the nucleus determines which element the atom belongs to. Each time a proton is added to the nucleus to make a new element, an electron is added to the atom's outer ring so that the atom remains electrical neutral. We've also learned that since there are over 100 elements in the periodic table, the largest atoms must have over 100 protons in their nucleus.

We've also learned that protons, being electrically positive, repel each other but are able to stay together in the nucleus because of the strong force exerted by the protons and neutrons right next to them. The reason neutrons are able to exert a strong force is that neutrons are made from a proton and an electron.



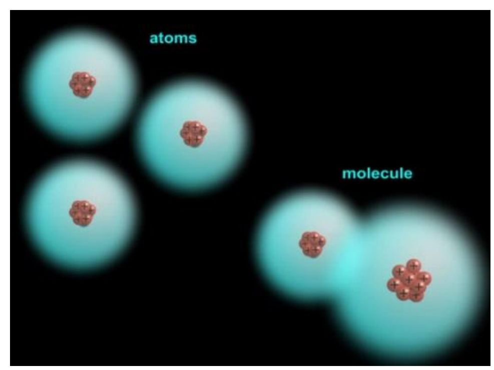
Regarding the strong force, we've learned that the strong force's reach is extremely short and thus can only pull protons together when the protons are extremely close to each other.

As for the electron circling the nucleus, Ring 1 can hold only two electrons, while Rings 2 and 3 can each hold eight electrons.

What we've learned about neutrons is that they stabilize the nucleus by nudging protons apart to lessen their mutual repulsion, and by exerting a strong force on neighboring protons. We've also learned that the number of neutrons in the nucleus can vary even within atoms of the same element. Atoms of the same element with different numbers of neutrons in their nucleus are called "isotopes."

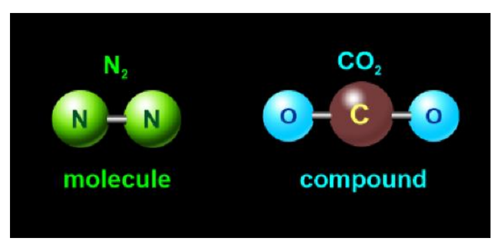
Each additional neutron in an isotope adds a tiny bit of weight to that isotope, but chemically, all isotopes of an element act pretty much the same way.

Slide 14: Why atoms bond



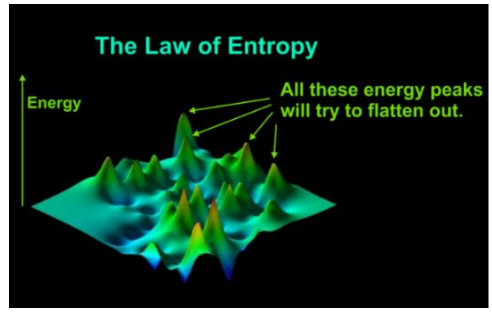
The electron clouds around every atom make every atom repel every other atom. And yet, almost all of the atoms in the periodic table are willing to overcome their mutual repulsion and bond with other atoms in the periodic table to form molecules.

Molecules are two or more atoms bonded together, and almost everything in the world is made up of molecules, not free-standing atoms.



Two atoms of the same element can bond to each other, as can two atoms of different elements. A "compound" is a molecule containing atoms from two different elements. So, a molecule of nitrogen with two nitrogen atoms is just a molecule, but a molecule of carbon dioxide, CO_2, with one carbon atom and two oxygen atoms, is not only a molecule, but also a compound.

What's driving atoms to form molecules? The need to find the lowest energy state possible. Every atom wants to be at the lowest energy state possible where it's calm, stable and relaxed.

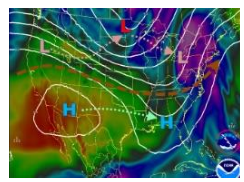


The need to reach a lower energy level is one of the driving forces in the universe, called the Law of Entropy. The Law of Entropy says that nature cannot tolerate energy being concentrated in any one location. Since energy can never be destroyed, nature is forced to spread energy out so that it's equal everywhere.

We see this all around us. A river flows downhill, a hot cup of coffee cools off, and high air pressure pushes outward until its pressure equals it surroundings. These are all examples of energy not wanting to be concentrated in any one place.

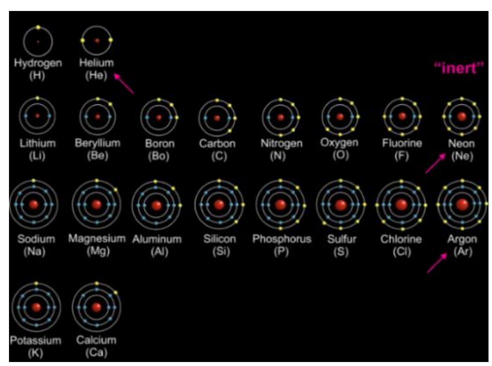
The result of spreading energy out is that things become less organized and more chaotic. In a sense, entropy is a measure of disorder.





Slide 15: Bonding with other atoms

Atoms will ignore each other's electron repulsion and bond with each other if it means they can rid themselves of their excess energy.



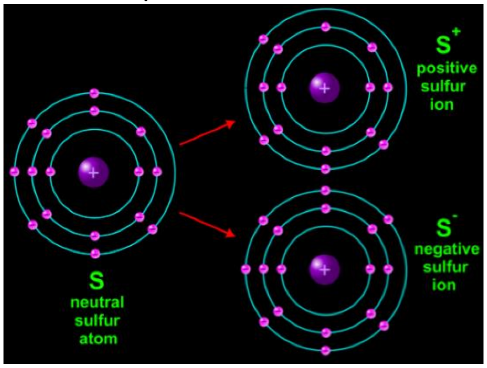
Atoms with unfilled outer rings are at a higher energy level than when their outer rings are filled. They desperately want to shed themselves of that excess energy, and the most direct way to do that is to totally ignore the electron cloud around another atom and bond with the atom in such a way that both atoms fill up their outer rings and achieve a lower, more desirable energy level.

Helium, neon, and argon aren't driven to fill up their outer rings, because their outer rings are already filled. These three elements are so stable and relaxed that they have no reason to bond with other elements in the periodic table, and are, therefore, "inert," meaning chemically inactive.

The good news for all the other atoms in the periodic table is that electrons can easily be moved around to fill up their outer rings. We showed that with the van der Graaf generator.

You do the same thing by rubbing a balloon against your hair and scraping electrons off your hair onto the balloon, or by simply walking across a carpet in the winter when the air is dry. As you reach for a doorknob, all the electrons you rubbed off the carpet suddenly leap to the doorknob and produce an electrical shock. Moving electrons through a wire is the basis for electricity.

Removing an electron from an atom leaves the atom with more protons than electrons. An atom with an unequal number of protons and electrons is called an "ion." A "positive ion" is an atom with more protons that electrons, and a "negative ion" is an atom with more electrons than protons.

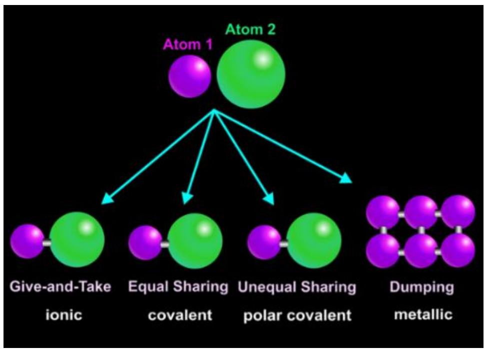


An ion is still an atom, simply an atom with an unequal number of protons and electrons.

Also, removing an electron from an atom, or adding an electron to an atom, does not turn the atom into a new element. Only by adding or removing protons in the nucleus can an atom become a different element.

Slide 16: Intramolecular bonding

Atoms have figured out four ways to move their electrons around in order to bond to other atoms and thereby fill their outer rings. One way that some atoms bond to other atoms is by giving their outer electrons to another atom and the other atom taking them. This bond is called the "ionic bond."



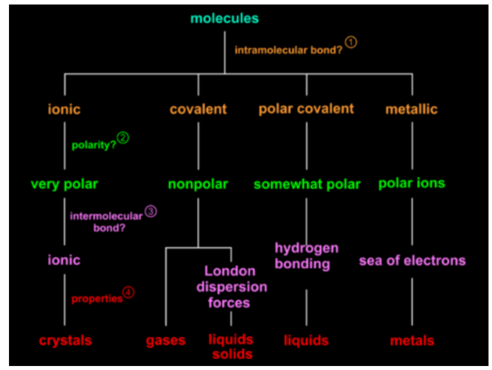
The second way that two atoms fill up their outer rings is by sharing electrons equally between them, called the "covalent bond."

The third way two atoms bond is by sharing electrons, but sharing them unequally, in other words, one atom hogging the shared electrons. This third bond is called the "polar covalent bond."

And the fourth method of bonding is by a group of identical atoms dumping all their outer electrons into a sea of electrons to run free. This fourth bond is the "metallic bond."

All four of these bonds are "intramolecular" bonds, meaning they bond atoms within the molecule – "intra" means within.

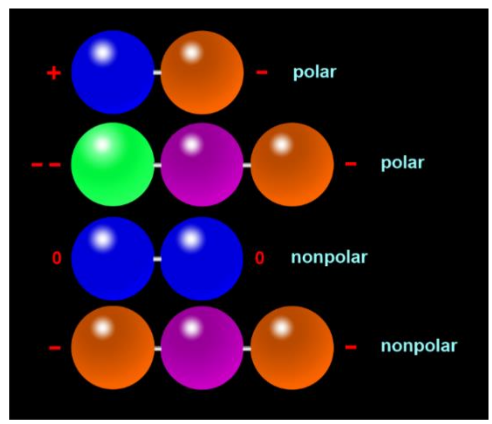
Slide 17: Overview of intramolecular and intermolecular bonding



This flow chart gives an overview of where we're going next, beginning at the top with the four intramolecular bonds, and ending at the bottom with the properties of the substances made up of molecules assembled with each type of intramolecular bond.

In the upcoming lessons, we're going to learn how each intramolecular bond (shown in orange) determines the "polarity" of the molecule (shown in green).

Polarity is the difference in electrical charge on the two sides of the molecule. The greater the difference in electrical charge on the two sides of the molecule, the greater the polarity. Polarity occurs, of course, when one side of the molecule is positive and the other side negative, but polarity also occurs when both sides of the molecule are negative so long as one side is more negative than the other side, because what makes a molecule polar is the difference in electrical charge on the two sides of the molecule. Asymmetrical negative electrical charges commonly occur on large proteins, making those two sides of the protein polar. A "nonpolar" molecule, then, can mean either both sides have no electrical charge at all – both sides have zero electrical charge, or that both sides have the same electrical charge and there's no difference between the two sides.

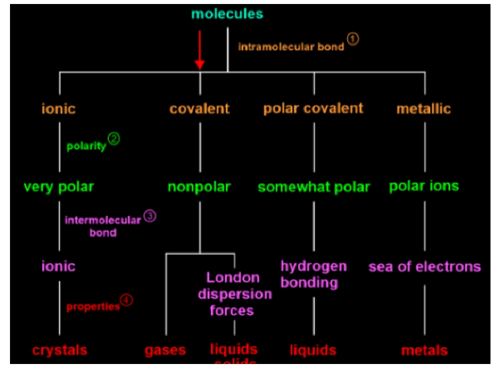


We're then going to learn how the polarity of a molecule makes one molecule stick to another molecule in what's called an "intermolecular bond" -- "inter" means between.

And finally, we're going to learn that even though the intermolecular bond between two molecules is much weaker that the intramolecular bond between two atoms, the intermolecular bond determines the properties of the substance made up of those molecules.

In short, the intramolecular bond determines polarity of the molecule, polarity determines how sticky the molecule is, and the magnitude of the stickiness determines the properties of the substance.

Slide 18: Properties of molecules



In the next few lessons, we're going to find out that molecules formed with ionic intramolecular bonds tend to be very polar, molecules formed with covalent intramolecular bonds are nonpolar, molecules formed with polar covalent bonds are somewhat polar, and atoms bonded to other atoms with metallic bonds don't even form molecules but instead, bond to each other as positive ions.

What we'll discover about polarity is why highly polar ionic molecules bond tightly to other ionic molecules and form crystals that crack easily when tapped, and why covalent intramolecular bonds produce nonpolar molecules that generally ignore each other and bounce away as gases. We'll also see how a special force called "London dispersion force" is able to pull even nonpolar molecules together and form liquids or even solids. We'll see why polar covalent bonds produce somewhat polar molecules that stick weakly to each other and tend to form liquids. And finally, we'll see why metallic intramolecular bonds produce rows and columns of highly polar ions that stick very tightly to each other as metals.

I hope you see from this flow chart that once you understand the four intramolecular bonds, the rest of chemistry will all make sense. So, throughout the rest of this chemistry course, focus on four things about any molecule.

1) Which intramolecular bond was used to bond the atoms together?

2) Based on the intramolecular bond, what is the resulting polarity of the molecule?

3) Which intermolecular bond is holding the molecules together?

4) Based on the particular intermolecular bond between molecules, what properties do you predict will be present in something made up of these molecules?

We are now going to spend a good deal of time exploring each of these intramolecular bonds, beginning in the next lesson with the ionic bond.

Slide 19: What You Know So Far

1. Two or more atoms bonded together are called a "molecule."

2. The Law of Entropy says that peaks of energy tend to flatten out by shedding energy.

3. The Law of Entropy drives atoms to bond to other atoms if, in doing so, both atoms can fill up their outer rings and lower their energy state.

4. Electrons can be removed or added to atoms, in which case the atoms become ions.

5. An atom with more protons than electrons is a positive ion. An atom with fewer protons than electrons is a negative ion.

6. An ion is still an atom -- an atom with an imbalance of electrical charges.

Slide 20: What You Know So Far

7. Adding or removing an electron does not make the atom into a new element. Only changing the number of protons in the nucleus changes the atom into a different element.

8. Atoms use four ways to bond to other atoms and fill up their outer ring.

9. Polarity is the difference in electrical charge on opposite sides of a molecule.

10. Each of the four intramolecular bonds produces molecules with varying polarity.

11. The magnitude of molecular polarity determines the strength of the intermolecular bond.

Slide 21: What You Know So Far

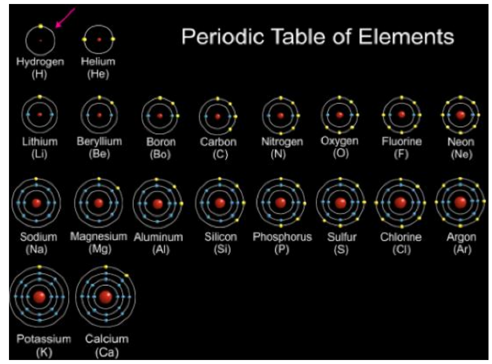
12. The intermolecular bond is the attraction one molecule has for another molecule, in other words, how sticky the molecules are.

13. The strength of the intermolecular bond determines the properties of the substance made up of those molecules.

Familiarize yourself with the elements (Linked from Slide 3)

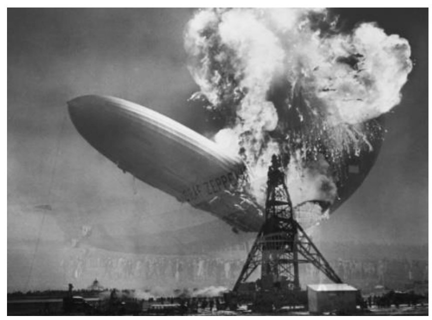
Slide 1: Hydrogen

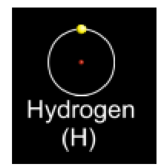
The first 20 elements of the periodic table may seem strange to you but, really, they're all around you. Take hydrogen.



Hydrogen is a very small atom and for this reason, hydrogen gas is very light.

In the 1920's and 30's, hydrogen was used to lift large zeppelins carrying many passengers, until 1937 when the hydrogen-filled Hindenburg exploded from an electrical spark while landing in New Jersey.





Slide 2: Helium

Element number 2 in the periodic table is helium. Have you ever seen helium gas used?

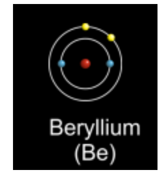
Helium gas is used to inflate party balloons from large tanks of helium.

Like hydrogen, helium is a very small, light atom and will cause balloons to float to the ceiling, but unlike hydrogen, helium does not explode.

Slide 3: Lithium

The next element, element number 3, is lithium. You know where we find lithium? In strong batteries. Lithium batteries are so strong, they can run power tools that don't need to be plugged into the wall.

Slide 4: Beryllium

The next element is beryllium which has four electrons circling around it, two electrons in Ring 1 and 2 in Ring 2. Beryllium is pretty rare, but it's found in emeralds. Here is an emerald necklace.

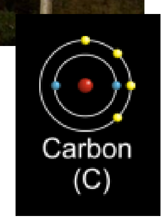
Slide 5: Boron


The next element with five electrons is boron. Boron is found in Borax, a detergent booster, which means it helps detergents clean your clothes. Boron is also used in small amounts to fertilize plants and strengthen their cell walls.

Slide 6: Carbon

The next element has two electrons in Ring 1 and four electrons in Ring 2. That element is carbon. Have you ever eaten carbon?

This burnt marshmallow is carbon. Any time we overcook food and burn it, that black stuff is carbon. In fact, every food we eat has atoms of carbon in it.

The coal we burn to get warm and the charcoal we heat in the grill are also carbon, but don't try to eat either one, because there are other things in coal and charcoal that make them poisonous.

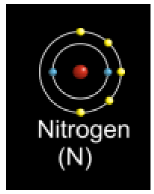
Slide 7: Nitrogen and Oxygen

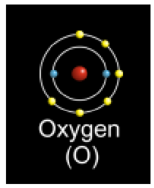
Adding an electron to carbon we get nitrogen. Most of the air we and these penguins breathe is nitrogen, but our bodies don't use that nitrogen. The reason we breathe is to inhale the next atom, the atom with six electrons in Ring 2, oxygen.

Oxygen is needed for combustion, and we breathe in oxygen for the same reason. We need the oxygen in the air to burn our food and release the energy in food to run our bodies.

Some people need extra oxygen because cigarette smoke damaged their lungs. So, instead of breathing air, which is mostly nitrogen and only some oxygen, they have to breathe extra oxygen from a tank of oxygen that they drag behind them.

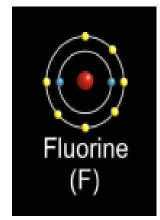
Football players sometimes get short of breath and for a few minutes have to breathe pure oxygen to regain their strength.





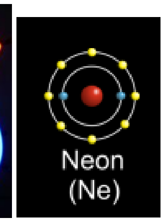
Slide 8: Fluorine

The next element is fluorine with seven electrons in Ring 2. We use fluorine every day. They put fluorine atoms in toothpaste because fluorine makes our teeth strong enough to prevent cavities. This tube of toothpaste says “contains fluoride.” That means it contains atoms of fluorine.



Slide 9: Neon

The next element in Ring 2 is neon. Neon is used to make different colored lights. I’m sure you’ve seen neon lights advertising stores and products.

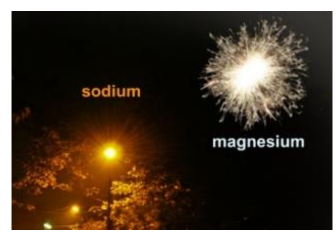


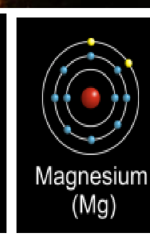
Slide 10: Sodium and Magnesium

There’s no more room in Ring 2. Ring 2 is filled up when it has eight electrons. So, if we add another electron, it has to go into Ring 3. The first element in Ring 3 is sodium with one electron in Ring 3.

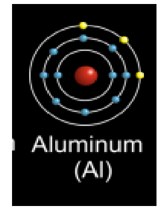
Pure sodium is uncommon. The only time we really see sodium is at night. Streetlights often burn sodium which gives off a bright orange light.

Magnesium, on the other hand, with two electrons in Ring 3, gives off a bright white light when it burns, which is why magnesium is often used in sparklers.





Slide 11: Aluminum/Silicon



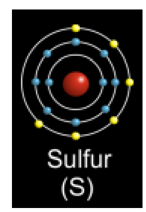
Aluminum has 3 electrons in Ring 3, and you're all familiar with aluminum.

What about silicon with four electrons in Ring 3? Silicon is very common because ordinary sand is simply silicon bound up with oxygen.

Slide 12: Phosphorus

The next element is phosphorus with five electrons in Ring 3. The major use of phosphorus is in fertilizers. Phosphorus is right below nitrogen on the periodic table and both nitrogen and phosphorus are commonly used in fertilizers. Phosphorus ignites easily and is frequently used in fireworks.

Slide 13: Sulfur



The element with six electrons in Ring 3 is sulfur, a yellow element with many different uses, most of which we are unaware of until we encounter the smell of sulfur in farts and rotten eggs.

Slide 14: Chlorine

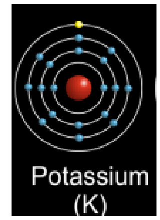
The next to last element with seven electrons in Ring 3 is chlorine which is what we smell in indoor swimming pools where chlorine bleach is added to the water to kill any harmful bacteria. We also use chlorine at home to bleach out stains and keep white clothes super white.

Slide 15: Argon

The last element in Ring 3 is argon. With its filled Ring 3, argon is very stable. For this reason, argon is sometimes used when welding two metals together, to block other elements like oxygen from interfering with the weld.

Slide 16: Potassium

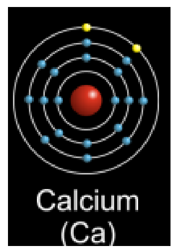
Now that Ring 3 is filled, the next electron must go into Ring 4 to form potassium. Potassium is present in high concentration in every cell of our body. Potassium is also a necessary element for plants, as nitrogen and phosphorus are. In fact, when you buy fertilizer, the three numbers displayed on the fertilizer bag refer to the percentage of nitrogen, phosphorus, and potassium in the fertilizer. N stands for nitrogen, P for phosphorus, and K for potassium.



Slide 17: Calcium

Our last element is calcium with two electrons in Ring 4. Calcium, we all know, is needed for strong bones and strong teeth.

Calcium is also the major element in concrete and cement.



Slide 18: Review

Here are the first 20 elements in the periodic table.

Which element do football players breathe when they get short of breath? Oxygen

Which element is the lightest? Hydrogen

Which element is inside party balloons that float up to the ceiling? Helium

Which three elements are found in a typical bag of fertilizer? Nitrogen, Phosphorus, and Potassium

Which element is in toothpaste? Fluorine

Which element is stinky? Sulfur

Which element makes up most of the air we breathe? Nitrogen

Which element gives us the color in electric signs? Neon

Which element makes our bones strong? Calcium

Which element in small amounts is needed for plant growth? Boron

Which element is used in fireworks? Phosphorus

Which element do we wrap foods in to keep them fresh? Aluminum

Which element is sand made of? Silicon

Which element is in bleach? Chlorine

Which element burns bright orange and is used at night in streetlights? Sodium

Which element makes cement so strong? Calcium

Which element burns bright white? Magnesium

Which element do we burn in barbecues? Carbon

Which element allows us to burn our food to make energy? Oxygen

Which element powers strong batteries? Lithium

Which element is found in emeralds? Beryllium

Which element is found in burnt toast? Carbon

Which element, needing no electrons to fill its outer ring, is used in welding? Argon

Which element is in high concentration in every cell of our body? Potassium

Now let's return to Lesson 1. Return to Lesson