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Quelling Fear of Chemistry: A Method Designed for the Incorporation of General Chemistry concepts into the Education of Elementary and Middle School Students

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Introduction:

First year students frequently encounter anxiety when learning chemistry attributed to feeling as if they cannot answer questions correctly on exams and will therefore not pass the class (McCarthy & Widanski, 2009). Reactions to this anxiety have ranged from "calming exercises" in class to rearranging course material with varied success (Abendroth & Friedman, 1983).

Psychology explains that students learn best when they have prior exposure to the subject rather than viewing it as a completely new area of learning. This concept is exemplified in the teaching of algebra: many years ago, elementary mathematics was arithmetic, but in more recent years, elements of algebra have found their way into what is known as elementary algebra, which introduces such ideas as solving for a variable even to students too young to conceive mathematics as an extension of a placement within a defined coordinate system (*Algebra: Gateway to a technological future*, 2011). This system allows students to feel comfortable with some parts of algebra before taking an actual course in the subject so as to not overwhelm them in that class. It is important to note that the exposure to Algebraic concepts in elementary and middle school does not replace the actual class, but rather serves to make concepts more familiar and thus more accessible to students.

It stands to reason that the psychology involved in the teaching of algebra would also extend to the teaching of chemistry. Incorporating chemistry in the earlier years of students' education should, based on the psychology of learning proven through the algebraic learning process, make learning easier and less stressful for students. Thus, it is necessary to find a way to incorporate chemistry in the elementary and middle school curriculum to make students more familiar with basic chemistry concepts.

One major difficulty of chemistry lies in the abstract nature of many of the concepts dealing with the microscopic world, a world too small for a child's brain to comprehend (Sirhan, 2007). This difficulty is a large part of why many elementary and middle school curriculums say away from the mention of chemistry all together. However, elementary school students learn about the earth as a sphere spinning around at in incomprehensible speed while orbiting a sun far too large to fully comprehend, moving along with other spheres most of which are larger than this sphere the students are standing on along with billions of other people ("Fcat 2.0 science," 2011). All of these things are happening in a vacuum, a space in which there is nothing. Those ideas sound like very abstract concepts. Why should the discussion of things too small to imagine be significantly more abstract and difficult than discussion of things too large to comprehend? Quite simply, it should not be.

Many teachers utilize projects in which students are required to make a model of the solar system; often times, students are required to draw pictures of the solar system ("Pro teacher: Solar," 2012). In short, teachers approach the subject in a way that forces students to take concepts from incomprehensibly large to a size they can visualize and comprehend. There is absolutely no reason why, when given perspective in the tangible world, elementary school students cannot understand the incomprehensibly small as well as they understand the incomprehensibly large. Thus, the first approach I took in these methods to incorporate chemistry into the elementary and middle school curriculum was to present some of the ideas about chemistry in a way that related the size to something students had experienced. I chose to relate the size of a very small "germ" to the size of a football field and the size of an atom to the student standing in the field. This relationship was extended to include concepts bonding and intermolecular forces.

Additionally, students learn in many different ways, often times overlapping music and/or kinesthetic movements and games with concepts they learn in school (Jensen, 2005). Thus, the next method I utilized to incorporate chemistry into the elementary and middle school curriculum was to make up songs to the tune of songs with which many of the students should be familiar that explain some basic chemistry concepts, especially those which tend to confuse students. For example, it is common for students to become confused about whether acids or bases are proton donors, and which of them accepts electrons in acid-base chemistry. Therefore, I created two songs to be sung to the tune of “I Was Strolling through the Park One Day” to help clear up these difficulties and allow students to more easily remember the information, perhaps even before they can understand what the words mean.

Next, I designed movements that bring micro- and nanoscopic chemical concepts to the tangible world. For example, covalent bonding occurs when one student is holding an electron – in this case a large cardboard minus sign – and another student comes by and takes the electron, but the first student does not let go. Both students hold on and “share” the electron. To further cement ideas into student’s heads, I designed games to illustrate concepts while allowing students to have fun. For instance, a couple games resembling “red-light, green-light” illustrate and test concepts from acid-base chemistry.

However, in the current educational climate, those methods would likely have a limited impact. Education is currently trending towards standardized testing and merit-based pay (Turner, 2010). In the state of Florida, emotional disorder associated with the stress of the state's standardized test, known as the FCAT, cause psychologists to hospitalize children ("7 tips for," 2011). Teachers and students often feel so pressured to perform very well on the test over their current curriculum that convincing teachers to implement chemistry concepts into their current science curriculum would be difficult, bordering the nearly impossible.

Thus, I decided on my third and final method for incorporating chemistry into the elementary and middle school curriculum: connecting chemistry concepts to mathematical concepts already in the curriculum. The worksheets I created offer a way for students to utilize mathematical concepts that they are already learning as a tool to understand chemistry concepts and to even solve some basic chemistry problems. However, since each of these stand-alone worksheets focuses on only one math skill, and they do not delve very deeply into chemistry concepts, the teachers can utilize them as just another tool to allow students to practice math skills. The students, however, will gain some knowledge of chemistry and of problem solving, and at least feel vaguely familiar with the subject when they reach it in high school or college.

Further, this third method of incorporating chemistry helps address another major issue: at the high school and college level, many students struggle to connect the algebra and arithmetic they learned earlier in their education with the general chemistry problems they are solving (Blakely, 2011). In elementary school, science is geared more towards memorizing than solving problems or understanding difficult concepts (Fogarty, R., & Stoehr, J.,1995). Introducing chemistry as simply a unit among others in science classes would fail to teach students the problem solving skills necessary to solve chemistry problems. The problem solving skills would, therefore, be more related to the problems students learn in mathematics. Thus, this method not only takes the pressure of teaching a whole new subject area off of teachers, but also allows students to connect essential mathematical skills to learning chemistry.

If the third, and most easily implementable method was incorporated into elementary and middle school curriculum, teachers could be convinced that students can comprehend the chemistry presented in the worksheets. Ideally, this would inspire teachers and school board members to teach more and more chemistry in classrooms, thus utilizing the other methods.

Just as with Algebra, none of these methods is meant to take the place of a college chemistry course; in fact there are many aspects of a general chemistry course that are not even mentioned in this thesis. Many of these aspects have mathematical concepts or chemistry concepts that lie outside of the target age-groups ability to understand. Even though teachers may teach students about outer space, explaining to students gravitational force's effect on time is probably going to simply confuse students. Likewise, explaining to students in detail about quantum energy levels is going to confuse them and leave them disliking chemistry. Additionally, this thesis does not cover all of general chemistry because I want to work to implement part – and, ideally, eventually, this entire thesis – into surrounding schools. If I hand out many more pages of information for teachers, they would likely feel completely overwhelmed. In short, this thesis simply seeks to find ways to familiarize students with the idea of learning chemistry so that when they take a complete class in the subject later in their education, they do not form mental blocks due to fear of the subject.

Chemistry: An Introduction

<u>Atomic Structure:</u>

Have you ever lay in the middle of a football field? You are really small compared to the size of the field, right?

Do you remember that germs are so tiny you cannot see them; well there are things even smaller than germs. Imagine that the football field is a one of the tiniest germs; you, lying in the field, are about the size of an atom.

Matter is anything that takes up space. You are matter, tree is matter, a leaf is matter, and even the air you breathe is matter.

In order to take up space, **matter** has to be made up of something. The building blocks of all matter are **atoms**.

You have heard names of some **atoms** before. The oxygen you breathe in is made up of two oxygen **atoms** stuck together.

When two or more atoms are stuck together, they are called **molecules**. Have you ever heard of carbon dioxide? It is what you breathe out after your body uses the oxygen from the air you breathe in. Carbon dioxide is made up one carbon atom and two oxygen atoms stuck together.

Now, you may be wondering, "What about a tree, a penny, or me? If everything is made of atoms and connected atoms make up molecules, does that make me a really big molecule?" To put it simply, no.

Now imagine you are back in that football field, but now the field is packed with other students each representing an atom. You link arms with your two friends. You and your friends make up a molecule. The rest of the students on the field are not in the molecule, but they are still near you. If you put hundreds and hundreds of these fields full of students together you would get matter you can see.

The links that you formed with your friends are called **bonds**. Bonds are what hold molecules together.

<u>Bonds:</u>

Imagine you are on a football field packed with other students. Each student represents an atom. You link arms with your two friends. You and your friends make up a molecule. The rest of the students on the field are not in the molecule, but they are still near you. If you put hundreds and hundreds of these fields full of students together you would get matter you can see.

The links that you formed with your friends are called **bonds**. Bonds are what hold molecules together.

But what makes those bonds strong?

These tiny atoms are made up of even smaller pieces called **subatomic particles**. There are three types of subatomic particles: **protons**, **neutrons**, and **electrons**. Protons have a positive charge, electrons have a negative charge, and neutrons have no charge. You can think of this charge kind of like a magnet. If you put the positive end of a magnet together with a negative charged end of a magnet, they stick together. In the same way, the negatively charged **electrons** are attracted to the positively charged **protons**. If there are more protons in an atom, there is a stronger positive charge. Therefore, each negatively charged electron would be more attracted to the atom containing more electrons. This relationship leads to **bonds**: the force that holds molecules together.

There are three types of **bonds: polar covalent bonds, nonpolar covalent bonds,** and **ionic bonds**.

When an atom comes near another atom sometimes the pull of the protons in one atom pulls an electron away from the other atom. **Covalent bonding** occurs when the pull of the protons is not enough to completely pull the electron away and the atoms end up "sharing" the electron.

Even though the electron is being shared, sometimes the hold that one atom has on the electron is stronger than the other. This is called a **polar covalent bond**. A nonpolar covalent bond occurs when the electron is shared equally.

What happens if the pull of the protons is so strong that the electron is completely taken away from an atom? One atom has one electron, which gives it a positive charge. The other atom has one more electron, which gives it a negative charge. Do you remember what happens to positive and negative charges? They are attracted to each other! Each of these charged atoms finds an atom of the opposite charge and forms sticks together forming an **ionic bond**.

Intermolecular Interactions:

Imagine that you are back on that field surrounded by all your fellow students linked with a couple of your friends. You have now learned what is keeping your friends linked to you to form molecules, but why are your classmates, representing other molecules, still near you? What is keeping them from running away from you? What keeps enough molecules together that we can actually see **matter**?

In short, intermolecular forces cause different molecules to stick to each other.

In polar covalent bonds the electron is being shared, but one atom has a stronger hold on the electron, pulling it closer to that atom. Since this negative charge is a little closer to that atom with the stronger pull, that atom ends up with a partially negative charge. The other atom, which has a little less of the electron, ends up with a partially negative charge. Remember that differences in charge cause attraction.

Therefore, the partial positive charge on one atom of a molecule is attracted to the partially negatively charged atom of a different molecule.

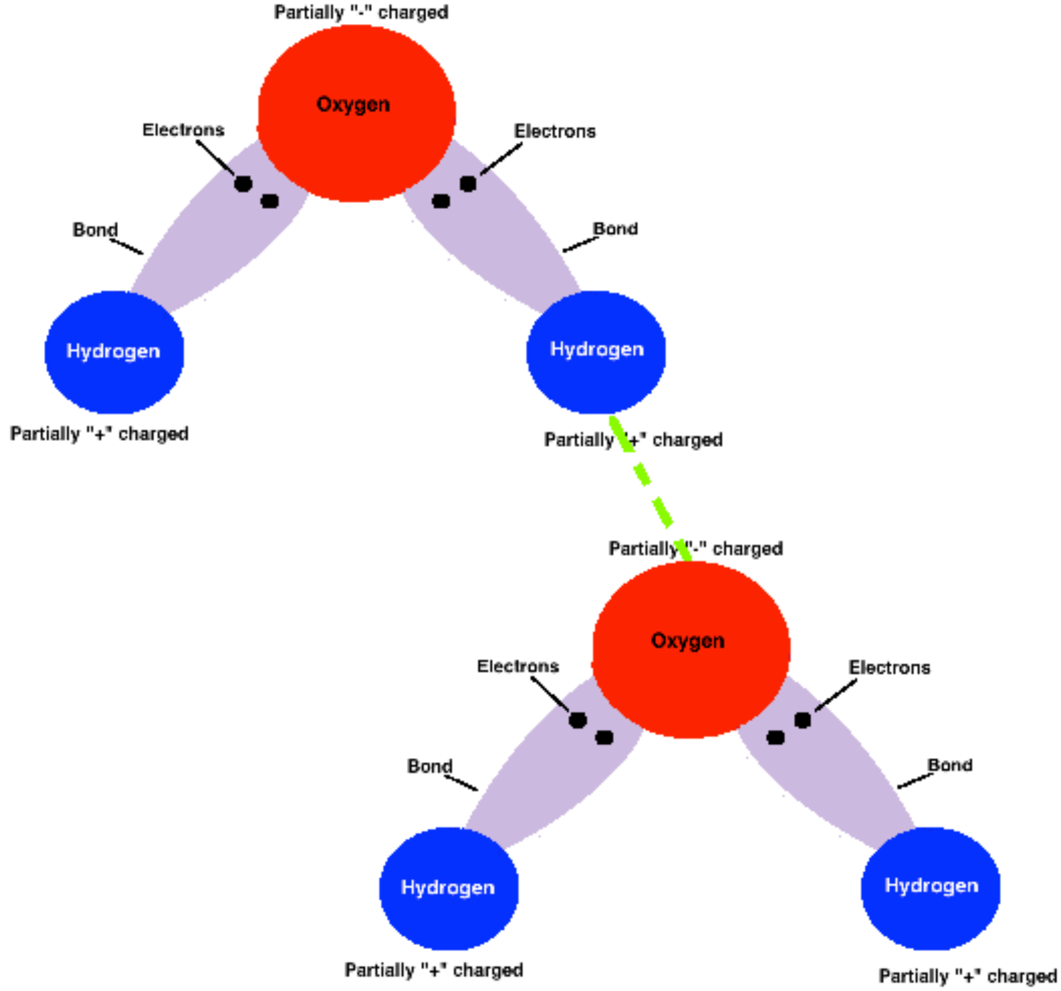
Since these partial charges are not as strong as those in ionic bonding, a bond does not occur between the atoms interacting, the atoms just tend to stay close to each other.

A good example of this is water. Water is made of two hydrogen atoms and one oxygen atom. The electrons are much more attracted to the oxygen than the hydrogen.

Look at the picture on the next page.

As you can see, the electrons' nearness to the oxygen atom makes the oxygen atoms partially negatively charged and hydrogen atoms partially positively charged. That partially positively charged hydrogen interacts with partially negatively charged oxygen. This interaction makes the water molecules stick together.

Since these charges are only partially positive, this kind of attraction does not make atoms stick together as much as the stronger charges of ionic bonding. That is why this type of interaction does not cause bonding. It just causes the atoms to stick to each other enough for you to see matter.


Partially "-" charged
Oxygen
Electrons
Electrons
Bond
Bond
Hydrogen
Hydrogen
Partially "+" charged
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Oxygen
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Partially "+" charged

Songs, Movements, and Games

Acid-Base Chemistry:

Song:
Acids and Bases (Hydrogen Version):

<u>Hydrogen Was With a Acid One Day (To the tune of I was Strolling in the Park One Day):</u>

Hydrogen was with an acid one day,
In the very merry month of May
Until he was taken by surprise, by Miss Base coming by
And then his little heart was stolen away.

(This is the end of the shorter Version)

A new home, she gave to him

(Musical Interlude)

Of course they were as happy as can be

(Musical Interlude)

Until one day she remarked…

I never, never shall forget
The hydrogen I met, on that lovely afternoon
That happy day while strolling by that acid.

Movement:
<u>Hydrogen Was With a Base One Day (To the tune of I was Strolling in the Park One Day):</u>
To have your students move to illustrate this song, you can have a student representing an acid link arms with one representing a hydrogen atom. Have a student representing Miss Base walk by. Have hydrogen break his arm link with acid and link his arms with Miss Base.

Game:
Acid-Base (Hydrogen):

Designate two sides of the play area. Tell the students that they are hydrogen atoms on an acid. Tell them whatever you shout out is passing by, and if it would cause them to move off of the acid, they have to move to the other side (a wall, a line, or whatever you designate). Shout “acid” or “base”. The students who move when you shout “acid” are out.
This game can be played in two ways, depending upon the how active your students need to be. The first way requires them to move run to the other side of the play area each time

they are supposed to move; in this version the student who reaches the other side last can also be "out". The second version is similar to "red-light, green light" except the "red-light" is "acid" and "green light" is "base;" thus, when you shout "acid," the students move, and when you shout base, they have to stop moving. If you shout, "base" and a student starts to move, that student would be "out".

If you have more advanced students; you can shout out specific molecules and they have to decide whether each molecule is an acid or base and, based upon their decision, if they should move.

Song:

Acids and Bases (Electron Version):

<u>Mr. Electron Was With an Base One Day (To the tune of I was Strolling in the Park one Day):</u>

Mr. Electron was with a base one day
But the acid said that was not the way
So Electron said okay
And jumped up on his way
To be with the acid all day.

Movement:

<u>Acids and Bases (Electron Version):</u>

To have your students move to illustrate this song, have a student representing an acid link arms with a student representing Mr. Electron. Have a student walk representing the base walk by and have Mr. Electron break his arm link with acid and link his arms with base.

Game:

Acid-Base (Electron):

Designate two sides of the play area. Tell the students that they are electrons on a base. Tell them whatever you shout out is passing by, and if it would cause them to move off of the base they have to move to the other side (a wall, a line, or whatever you designate). This game can be played in two ways, depending upon the how active your students need to be. The first way requires them to move run to the other side of the play area each time they are supposed to move; in this version the student who reaches the other side last can also be "out". The second version is similar to "red-light, green light" except the "red-light" is "base" and "green light" is "acid;" thus, when you shout, "acid," the students move, and when you shout base they have to stop moving. If you shout, "base" and a student starts to move, that student would be "out".

If you have more advanced students; you can shout out specific molecules and they have to decide whether each molecule is an acid or base and, based upon their decision, if they should move.

<u>Atomic Structure:</u>

Song:

<u>Them "Dem" Atoms (To the tune of Dem Dry Bones):</u>

Oh electrons are around the protons
The electrons are around the neutron
The electrons are around them both
And they all together make an atom.

Oh the first level has 2 electrons,
 The second level has 8 electrons
 The third level has 8 electrons
And they all together make an atom.

(Repeat Verses as Desired)

Movement:

<u>This movement section is designed to go specifically with the "Them "Dem" Atoms" Song</u>

Have a few students stand together and represent protons, and have a few students stand away from them representing neutrons. The rest of the students represent electrons.
1st line of song: Have electrons run around (circling) the protons (see figure 1).
2nd line: Have them run towards and around the neutrons (see figure 1).
3rd line: Have the protons and neutrons move together and the electrons run around circling both the protons and electrons (see figure 2).
4th line: Have the student stay in that formation and make note that their formation is the general structure of an atom (see figure 2).

Figure 1:

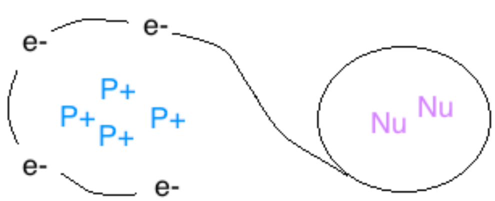
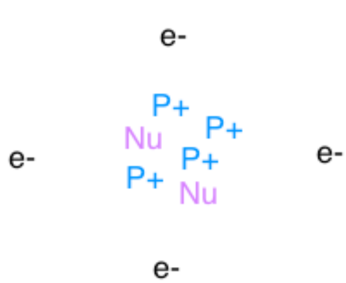


Figure 2:



Song:

Electrons Fly All Around (To the tune of the Green Grass Grows All Around):

There were some protons (repeat)
In the middle of an atom (repeat)
Those positive protons (repeat)
That are too small to see (repeat)
And electrons fly all around all around and electrons fly all around.

And by the protons (repeat)
There were some neutrons (repeat)
Those uncharged neutrons (repeat)
That are too small to see (repeat).
With the protons in the atom and the neutrons in the atom.
And electrons fly all around all around and electrons fly all around

---

Movement:
This movement is designed to specifically complement the song, "Electrons Fly All around and the figures refer back to the figures in the previous movement section.

Designate some students as protons, some as electrons, and some as neutrons (I would suggest making the most energetic students electrons).

Lines 1-4 (first verse) of song: Have your protons group together and sing these lines together while the electrons start to align themselves in a circle.
Line 5 (first verse): Have the electrons run around in a circle around the protons while singing this line.

Have your electrons stop moving temporarily.

Lines 6-9 (second verse): Have your neutrons join your protons in the center of the circle, and have just your neutrons sing these lines.
Line 10 (second verse): Your protons sing, "With the protons in the atom," and your neutrons sing, "And the neutrons in the atom"
Line 11 (Second verse): Have your electrons sing this line while running in a circle around the protons and neutrons (see figure 2)

Bonding:

Song:
Covalent Bonds (To the tune of Row Row Row Your Boat)

Covalent, covalent, covalent bonds share instead of steal
Happily happily happily happily their bonding's so friendly.

Movement:
Separate the students into groups of two or three. The students represent atoms. One student in each group should be holding a something to represent an electron (possibly a piece of cardboard cutout of a large negative sign). The student keeps holding on while the other students in his or her group place their hands on the "electron," sharing it.

Song:
Ionic Bonds (To the tune of Row Row Row Your Boat

Ionic, ionic, ionic bonds, steal instead of share; the get a charge and off they barge to bond with those left bare

Movement
Ionic Bonds:

Separate the students into groups of two. The students represent atoms. One student in each group should be holding something to represent an electron (possibly a piece of cardboard cutout of a large negative sign). The student other student takes hold of the "electron" and "steals it from the first student. The two students end the activity by standing near each other.

Game:
Ionic Bonds:

Separate the students into groups of two. The students represent atoms. One student in each group should be holding something to represent an electron (possibly a piece of cardboard cutout of a large negative sign). The student other student takes hold of the "electron" and "steals it from the first student. Now, you tell the students to run around and mix up. They now have to find their opposite (Students with an "electron" have to find students currently without an electron – theirs was stolen by the other students – and vis-versa.

Movement:

O_2 Versus H_2O
Have students get into groups of two and dance around holding hands. Explain to them that they are oxygen atoms. See how they are linked? That is how the oxygen we breathe (O_2) is linked together.

Now arrange the students in groups of 3 and dance around holding hands. Explain to them that they are now water; now one person in each group is oxygen and the other two are hydrogens. Their hands are linked in a similar way to water.

Game:

The previous “movement” section can be extended to a competitive game:

Shout out either oxygen or water. If you shout, “oxygen,” the students should form groups of two, if you shout, “water,” the students should form groups of three.

The last student(s) to form a group or the leftover student(s) who cannot form an entire group loose the round and the game continues until you reach you last two or three students.

For added difficulty, you could also add some other molecules such as H_2. Also, you can go around asking the members of the groups what atoms they represent. If, for example, two students in a water group say they are representing oxygen, they would be out.

Worksheets

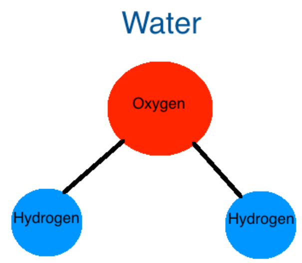
Fractions, Molecules, and Atoms:

Do you remember that germs are so tiny you cannot see them with your eyes? Did you know that there are things even smaller than germs?

Imagine a glass of water. It does not seem like it is made up of a bunch of tiny pieces, but that water is made up of very tiny water **molecules**.

Each of these molecules is made up of even smaller pieces called **atoms**!

Water is made up of 2 hydrogen atoms and one oxygen atom. This makes 3 total atoms in water.



Review Questions:

1.) Water is made up of ________atoms.
2.) Each water molecule has ____________ hydrogen atoms.
3.) Each water molecule has ____________ oxygen atoms.

Use questions 1-3 to answer questions 4-5.

4.) What fraction of the atoms in water is hydrogen atoms? ___________
5.) What fraction of the atoms in water is oxygen atoms? ____________

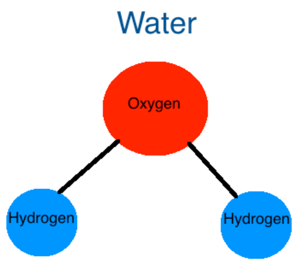
Fractions, Molecules, and Atoms (Answer Key):

Do you remember that germs are so tiny you cannot see them with your eyes? Did you know that there are things even smaller than germs?!

Imagine a glass of water. It does not seem like it is made up of a bunch of tiny pieces, but that water is made up of very tiny water **molecules**.

Each of these molecules is made up of even smaller pieces called **atoms**!

Water is made up of 2 hydrogen atoms and one oxygen atom. This makes 3 total atoms in water.



Review Questions:

1.) Water is made up of ________atoms. 3
2.) Each water molecule has ____________ hydrogen atoms. 2
3.) Each water molecule has ____________ oxygen atoms. 1

Use questions 1-3 to answer questions 4-5.

4.) What fraction of the atoms in water is hydrogen atoms? __________ 2/3
5.) What fraction of the atoms in water is oxygen atoms? __________ 1/3

Inequalities in States of Matter

Imagine touching a piece of ice. Brrrr! It is cold, right? It has a very low temperature – water freezes when it is cold. Ice is the name of the **solid** state of water.

Now, imagine swimming in a pool on a warm summer day. It may feel colder than the air, but this **liquid** water is much warmer than touching the ice, right?

Close your eyes, and remember when you have seen adult boil water. Maybe the adult was making pasta, rice, or tea. When the water got really hot, you could see something rising off the water, right? That something is called *steam* and it forms at really high temperatures. *Steam* is the name of the **gaseous** state of water.

Fill in the following blanks with a less than (<) sign or a greater than (>) sign.

1.) The temperature of ice is ________ the temperature of liquid water.
2.) The temperature of liquid water is __________ the temperature of steam.
3.) The temperature of steam is __________ the temperature of ice

Just like water, substances can be in a **solid** state, a **liquid** state, or a **gas** state. Just like water, at colder temperatures, substances will be in their solid state. At hotter temperatures, the substance will be a gas. At temperatures in between, the substance will be a liquid.

Fill in the following blanks with a less than (<) sign or a greater than (>) sign.

For the same substance…

1.) The temperature of the liquid state is ________ the temperature of the gaseous state.
2.) The temperature of the gaseous state is __________ the temperature.
3.) The temperature of steam is __________ the temperature of ice

Different states have different temperature ranges for each state. A glass of water sitting on the counter at room temperature is going to be a liquid. However, the oxygen in the air you breathe in the same room is in a gaseous state.

Just like water, if you made oxygen, really, really cold, it would exist in the liquid phase. If you made it even colder, oxygen would freeze and exists in its solid state! On earth it is never naturally that cold. That is why you have never seen liquid or solid oxygen. However, if you were on the surface of Jupiter, which is really far away from the sun, the same kind oxygen that we breathe would be a liquid!

You have seen changes in states of matter many times and may have never realized it! For example, the wax in an unlit candle is solid at room temperature. What happens when you light the candle and heat up the wax? The wax around the flame becomes a liquid!

Challenge questions (Hint: What state is the substance in at room temperature?)

1.) The temperature range of the gaseous state of oxygen is ________ the temperature range of the gaseous state of water.
2.) The temperature range of the solid state of water is __________the temperature of range of the solid state of wax.
3.) The temperature range of the solid state of wax is _______ the temperature range of the solid state of oxygen.

Inequalities in States of Matter (Answer Key)

Imagine touching a piece of ice. Brrrr! It is cold, right? It has a very low temperature – water freezes when it is cold. Ice is the name of the **solid** state of water.

Now, imagine swimming in a pool on a warm summer day. It may feel colder than the air, but this **liquid** water is much warmer than touching the ice, right?

Close your eyes, and remember when you have seen adult boil water. Maybe the adult was making pasta, rice, or tea. When the water got really hot, you could see something rising off the water, right? That something is called *steam* and it forms at really high temperatures. *Steam* is the name of the **gaseous** state of water.

Fill in the following blanks with a less than (<) sign or a greater than (>) sign.

1.) The temperature of ice is ________ the temperature of liquid water. <
2.) The temperature of liquid water is __________ the temperature of steam. <
3.) The temperature of steam is __________ the temperature of ice. >

Just like water, substances can be in a **solid** state, a **liquid** state, or a **gas** state. Just like water, at colder temperatures, substances will be in their solid state. At hotter temperatures, the substance will be a gas. At temperatures in between, the substance will be a liquid.

Fill in the following blanks with a less than (<) sign or a greater than (>) sign.

For the same substance…

1.) The temperature of the liquid state is ________ the temperature of the gaseous state. <
2.) The temperature of the gaseous state is __________ the temperature of the solid state. >
3.) The temperature of the solid state is __________ the temperature of gaseous state. <

Different states have different temperature ranges for each state. A glass of water sitting on the counter at room temperature is going to be a liquid. However, the oxygen in the air you breathe in the same room is in a gaseous state.

Just like water, if you made oxygen, really, really cold, it would exist in the liquid phase. If you made it even colder, oxygen would freeze and exists in its solid state! On earth it is never naturally that cold. That is why you have never seen liquid or solid oxygen. However, if you were on the surface of Jupiter, which is really far away from the sun, the same kind oxygen that we breathe would be a liquid!

You have seen changes in states of matter many times and may have never realized it! For example, the wax in an unlit candle is solid at room temperature. What happens when you light the candle and heat up the wax? The wax around the flame becomes a liquid!

Challenge questions (Hint: What state is the substance in at room temperature?)

1.) The temperature range of the gaseous state of oxygen is ________ the temperature range of the gaseous state of water. <

2.) The temperature range of the solid state of water is __________the temperature of range of the solid state of wax. <

3.) The temperature range of the solid state of wax is _______ the temperature range of the solid state of oxygen. >

Inequalities and Relative Speeds of Molecules:

What is matter?
Matter is anything that takes up space. Yes; that means you are matter, your teacher is matter, you pencil is matter, even your boogers are matter!

Just like water, all matter can be in different **states**. No, not states as in Florida, Georgia, or South Dakota. The states of matter are **solid** (like ice), **liquid** (like the water in a swimming pool or in the ocean), and **gas** (like steam). All matter is made up of particles even smaller than germs! They are so small that you cannot look under a regular microscope and see them! These particles are called **atoms** and **molecules**.
These molecules and atoms move around at different speeds at different temperatures.
Molecules and atoms in solids move the slowest.
Molecules and atoms in gasses move the fastest.
Molecules and atoms in liquids move at a speed in between.

Compare the speed of the molecules and atoms in the following with a (<) sign or a greater than (>) sign.

1.) The speed of the molecules in water is ________ the speed of the molecules in ice.
2.) The speed of the molecules in water is _________ the speed of the molecules in steam.
3.) The speed of the molecules in steam is _________the speed of the molecules in ice.

Inequalities and Relative Speeds of Molecules (Answer Key):

What is matter?
Matter is anything that takes up space. Yes; that means you are matter, your teacher is matter, you pencil is matter, even your boogers are matter!

Just like water, all matter can be in different **states**. No, not states as in Florida, Georgia, or South Dakota. The states of matter are **solid** (like ice), **liquid** (like the water in a swimming pool or in the ocean), and **gas** (like steam). All matter is made up of particles even smaller than germs! They are so small that you cannot look under a regular microscope and see them! These particles are called **atoms** and **molecules**.
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Compare the speed of the molecules and atoms in the following with a (<) sign or a greater than (>) sign.

4.) The speed of the molecules in water is ________ the speed of the molecules in ice. >
5.) The speed of the molecules in water is _________ the speed of the molecules in steam. <
6.) The speed of the molecules in steam is _________the speed of the molecules in ice. >

Note to teachers:

Your students may have questions about the difference between atoms and molecules. Atoms make up molecules. Each atom is composed of a combination of protons, electrons, and neutrons. One atom could be a hydrogen atom, a helium atom, an oxygen atom, or any other element on the periodic table. When atoms are combined, molecules are formed. This combination of atoms can be two of the same type of atoms, such as in the combination of two oxygen atoms in O_2, or the combination of two hydrogen atoms and one oxygen atom in H_2O.

Unit Conversions and Stoichiometry

Do you remember learning how to go from feet to inches?

There are 12 inches in 1 foot. This can also be written as $\frac{12 inches}{1 foot}$ or $\frac{1 foot}{12 inches}$.

So to find out how many inches are in 2 feet,

$2 feet \times \frac{12 inches}{1 foot}$ =24 inches. See how the feet (foot) cancel out; one is in the numerator and one is in the denominator.

Using that same concept, you can do CHEMISTRY!!!

Do you remember that germs are really, really tiny? Well, there are things even smaller than germs! They are called **molecules**. Plus, there are even smaller things called **atoms** that make up **molecules**!

Have you ever heard water called, "H_2O?" That name means that there are 2 hydrogen atoms and 1 oxygen atom in 1 water molecule. 2 atoms + 1 atoms = 3 atoms. So there are three atoms in one water molecule.

So…

1.) In water: ________ atoms = 1 molecule?
2.) This can also be written as $\frac{1 molecule}{\_\_\_\_\_ atoms}$ or $\frac{\_\_\_\_ molecule}{1 water}$
3.) So, to find out how many atoms are in 3 water molecules,

    $3 molecules \times \frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} = \_\_\_\_\_\_ atoms$

    Check your work. Does molecules in the numerator cancel with molecules in the denominator?
4.) Now, can you go the other way? How many water molecules are in 9 atoms in water?

    $9 atoms \times \frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} = \_\_\_\_\_\_ molecules$

    Check your work: Do "atoms" in the numerator cancel with atoms in the denominator?

Unit Conversions and Stoichiometry (Answer Key)

Do you remember learning how to go from feet to inches?

There are 12 inches in 1 foot. This can also be written as $\frac{12 inches}{1 foot}$ or $\frac{1 foot}{12 inches}$.

So to find out how many inches are in 2 feet,

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So…

1.) In water: ________ atoms = 1 molecule? 3
2.) This can also be written as $\frac{1 molecule}{\_\_\_\_\_ atoms}$ 3 or $\frac{\_\_\_\_ atoms}{1 molecule}$ 3
3.) So, to find out how many atoms are in 3 water molecules,

    $3 molecules \times \frac{\_\_\_\_\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_\_\_\_\_}$ 3atoms/1molecules = ______ *atoms* 9

    Check your work. Does "molecules" in the numerator cancel with molecules in the denominator?
4.) Now, can you go the other way? How many water molecules are in 9 atoms in water?

    $9 atoms \times \frac{\_\_\_\_\_\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_\_\_\_\_}$ 1molecules/3atoms = ______ *molecules* 3

    Check your work: Do atoms in the numerator cancel with atoms in the denominator?

Scientific Notation and Stoichiometry

Did you know that you can use scientific notation to do chemistry? Have you ever wondered how scientists know how many molecules they have when they measure chemicals?

The molecular weights given on the periodic table are in units of amu, but they are also in units of grams per mole.
Mole? Isn't that a mammal that burrows under the ground?

In chemistry, a mole is 602,000,000,000,000,000,000,000 molecule or atoms (that is a lot of molecules!). This number is known as Avagadro's number.
What is Avagadro's number in scientific notation?

____

One mole of an element weighs the weight of the atom from the periodic table in grams. For example: 1 hydrogen atom weighs 1amu so 1mol of hydrogen atoms (602,000,000,000,000,000,000,000 hydrogen atoms) weighs 1 gram.

One copper penny weighs 2.5 grams. How many copper molecules are in a penny?

To get from grams to molecules, we must first find moles: We go from grams→moles→molecules

So how do we get from grams to moles?

Each copper molecule weighs 64 amu. That means one mole of copper molecules weighs 64 grams:

$$\frac{64 grams}{1 mol} = \frac{1 mol}{64 grams}$$

$$2.5 grams \times \frac{1 mol}{65 grams} = 0.0385 mol$$

✔Check your work:

Does this answer make sense? Why or why not?

____

Write the number of moles in 2.5 grams of copper in scientific notation:

____

How do we get from grams to molecules?
We know that there are 602,000,000,000,000,000,000,000 copper atoms in each mole of copper.

$$0.0385 mol \times \frac{602{,}000{,}000{,}000{,}000{,}000{,}000{,}000 \text{molecules}}{1 moles}$$
$$= 23{,}200{,}000{,}000{,}000{,}000{,}000{,}000 molecules$$

What is the answer in scientific notation?

____

That is how many molecules are in a penny!
Molecules must be really tiny if that many can fit in a penny!

Now you try…

Two empty aluminum cans weigh 26grams total. How many aluminum atoms are in two empty aluminum cans?

An aluminum atom weighs 26amu, and therefore…
1 mole of aluminum weights 26grams.

1.) Using the information above, calculate the number of moles of aluminum present from the weight of the cans.

$$\_\_\_\_\_\_\_\_ grams \times \frac{1 mol}{\_\_\_\_\_\_\_\_ grams}$$

2.) Write Avagodro's number in scientific notation.

____

3.) Using your answers from numbers 1 and 2, find the number of atoms in the aluminum can.

$$\_\_\_\_\_\_\_\_ mole \times \frac{\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \text{molecules}}{1 mole}$$

✔Check your work:

Does this answer make sense? Why or why not?

____

____

Scientific Notation and Stoichiometry (Answer Key)

Did you know that you can use scientific notation to do chemistry? Have you ever wondered how scientist know how many molecules they have when they measure chemicals?

The molecular weights given on the periodic table are in units of amu, but they are also in units of grams per mole.
Mole? Isn't that a mammal that burrows under the ground?

In chemistry, a mole is 602,000,000,000,000,000,000,000 molecules or atoms (that is a lot of molecules!). This number is known as Avagadro's number.
What is Avagadro's number in scientific notation?

_________________________ 6.02×10^{23}

One mole of an element weighs the weight of the atom from the periodic table in grams. For example: 1 hydrogen atom weighs 1amu so 1mol of hydrogens (602,000,000,000,000,000,000,000 hydrogen atoms) weighs 1 gram.

One copper penny weighs 2.5 grams. How many copper molecules are in a penny?

To get from grams to molecules, we must first find moles: We go from grams→moles→molecules

So how do we get from grams to moles?

Each copper molecule weighs 64 amu. That means one mole of copper molecules weighs 64 grams:

$$\frac{64 grams}{1 mol} = \frac{1 mol}{64 grams}$$

$$2.5 grams \times \frac{1 mol}{65 grams} = 0.0385 mol$$

✔Check your work:

Does this answer make sense? Why or why not?

This answer makes sense because a penny weighs less than a mole of carbon; therefore, there should be less than a mole of carbon in a penny.

Write the number of moles in 2.5 grams of copper in scientific notation:

3.85×10^{-2}

How do we get from grams to molecules?
We know that there are 602,000,000,000,000,000,000,000 molecules in each mole of copper.

$$0.0385 mol \times \frac{602{,}000{,}000{,}000{,}000{,}000{,}000{,}000 \text{molecules}}{1 moles}$$
$$= 23{,}200{,}000{,}000{,}000{,}000{,}000{,}000 molecules$$

What is the answer in scientific notation?

2.32×10^{22}

That is how many molecules are in a penny!
Molecules must be really tiny if that many can fit in a penny!

Now you try…

Two empty aluminum cans weigh 26grams total. How many aluminum atoms are in two empty aluminum cans?

An aluminum atom weighs 26amu, and therefore…
1 mole of aluminum weights 26grams.

1.) Using the information above, calculate the number of moles of aluminum present from the weight of the cans.

26grams x (1 mole)/26grams = 1 mole

2.) Write Avagodro's number in scientific notation.
6.02×10^{23}grams/mole

3.) Using your answers from numbers 1 and 2, find the number of atoms in the aluminum can.
1mole x (6.02×10^{23}atoms)/1mole)=6.02×10^{23}atoms

✔Check your work: Does this answer make sense? Why or why not?

The answer makes sense because the weight of the can is equal to the weight of one mole of atoms.

Note to teachers (Scientific Notation and Stoichiometry):

Your students may be confused about the definition of a mole. It is just another way to write the number of atoms. The following explanation might be helpful. You know that you can measure the length of an object in inches. Then you can write that length in terms of feet, yards, or even miles. If something has a lot of inches, it might become time-consuming to write that really big number so we choose to write the number in feet, yards, or miles instead. For instance, if we measured the length of a portion of road to be 126,720 inches, it would be easier to write that number as 2 miles. Along the same lines, it is a lot easier to refer to amount of atoms as 2 moles of atoms rather than 1.2×10^{24} atoms.

Additionally, your students may have questions about the difference between atoms and molecules. Atoms make up molecules. Each atom is composed of a combination of protons, electrons, and neutrons. One atom could be a hydrogen atom, a helium atom, an oxygen atom, or any other element on the periodic table. When atoms are combined, molecules are formed. This combination of atoms can be two of the same type of atoms, such as in the combination of two oxygen atoms in O_2, or the combination of two hydrogen atoms and one oxygen atom in H_2O.

Lastly, it may be necessary to allow students to use a calculator or estimation strategies to solve the "now you try" portion of this worksheet.

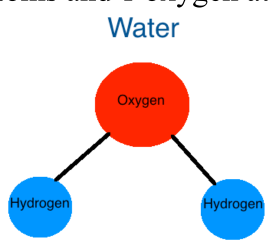
Finding Weights of Atoms with Multi-Step Addition and Multiplication:

Do you remember that germs are really, really tiny? Well, there are things even smaller than germs! They are called **molecules**. **Molecules** are made up of even smaller things called **atoms**!

Small things are weighed in units of ounces or grams. Big things are weighed in units of pounds or kilograms. Atoms and molecules are so small they have their own units of measurement called **atomic mass units**. Atomic mass units are written as “amu”. Unfortunately, we do not have scales that can measure units as small as atomic mass units.

So, how can we find the mass of a molecule? Let’s find out by considering water:

Have you ever heard water called, “H_2O?” That name means that there are 2 hydrogen atoms and 1 oxygen atom in 1 water molecule.



From the periodic table of the elements (a table of information about atoms), you can figure out how much each atom weighs.

Each hydrogen atom weighs 1amu.
Each oxygen atom weights 16 amu.

Because water has 2 hydrogen atoms, the weight from the hydrogen atoms is

$2 \times 1amu = 2amu$

Because water has 1 oxygen atom, the weight from the oxygen atoms is
$1 \times 16amu = 16amu$

So, to find the *total* weight of the water molecule, we add the weight from the hydrogen atoms and the weight from the oxygen atoms:
$2amu + 16amu = 18amu$
The total weight of a water molecule is 18amu!!!

Now you try!

When you breathe in air, your body uses oxygen, and you exhale carbon dioxide. How much does each molecule of carbon dioxide (CO_2) weigh? Carbon dioxide has 1 carbon and 2 oxygen atoms in it.
Each carbon atom weighs 12 amu
Each oxygen atom weighs 16 amu

a.) Because carbon dioxide has 1 carbon atom, the weight from the carbon atom is
_________ x __________=_____________

b.) Because carbon dioxide has 2 oxygen atoms, the weight from the oxygen atoms is
_________ x __________=_____________

c.) To find the *total* weight of one carbon dioxide molecule, we add the weight from the carbon atom and the weight from the oxygen atoms:
____________________ + ____________________=______________
(answer from a) (answer from b)

Exercises: Use the information from the following table to answer questions 1-3.

Name of Atom	Chemical Symbol	Weight of One Atom (amu)
Sodium	Na	23
Chlorine	Cl	35
Oxygen	O	16
Carbon	C	12
Hydrogen	H	1

1.) When you add salt to your food, you are adding NaCl. Each NaCl molecule has one sodium atom and one chlorine atom. What is the total weight of one molecule of NaCl?

____

____

____

2.) When you breathe in air, your body uses oxygen (O_2). Each of these oxygen molecules has two oxygen atoms stuck together. What is the total weight of one molecule of O_2?

____

____

____

3.) Challenge Question: Your parents may use vinegar ($C_2H_4O_2$) to cook or clean. Scientist call vinegar “acetic acid.” Acetic acid has two carbon atoms, four hydrogen atoms, and two oxygen atoms. Find the total weight of one molecule of Acetic Acid.

____

____

____

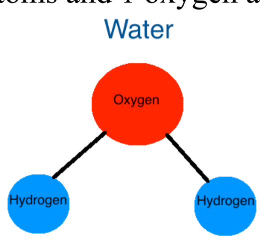
Finding Weights of Atoms with Multi-Step Addition and Multiplication (Answer Key):

Do you remember that germs are really, really tiny? Well, there are things even smaller than germs! They are called **molecules**. **Molecules** are made up of even smaller things called **atoms**!

Small things are weighed in units of ounces or grams. Big things are weighed in units of pounds or kilograms. Atoms and molecules are so small they have their own units of measurement called **atomic mass units**. Atomic mass units is written as “amu”. Unfortunately, we do not have scales that can measure units as small as atomic mass units.

So, how can we find the mass of a molecule? Let’s find out by looking at water:

Have you ever heard water called, “H_2O?” That name means that there are 2 hydrogen atoms and 1 oxygen atom in 1 water molecule.



From the periodic table of the elements (a table of information about atoms), you can figure out how much each atom weighs.

Each hydrogen atom weighs 1amu.
Each oxygen atom weights 16 amu.

Because water has 2 hydrogen atoms, the weight from the hydrogen atoms is

$2 \times 1amu = 2amu$

Because water has 1 oxygen atom, the weight from the oxygen atoms is
$1 \times 16amu = 16amu$

So, to find the *total* weight of the water molecule, we add the weight from the hydrogen atoms and the weight from the oxygen atoms:
$2amu + 16amu = 18amu$
The total weight of a water molecule is 18amu!!!

Now you try!

When you breathe in air, your body uses oxygen, and you exhale carbon dioxide. How much does each molecule of carbon dioxide (CO_2) weigh? Carbon dioxide has 1 carbon and 2 oxygen atoms in it.
Each carbon atom weighs 12 amu
Each oxygen atom weighs 16 amu

a.) Because carbon dioxide has 1 carbon atom, the weight from the carbon atoms is
__________ 1 x ___________ 12amu=______________ 12amu

b.) Because carbon dioxide has 2 oxygen atoms, the weight from the oxygen atoms is
__________ 2 x ___________16amu =______________ 32amu

c.) To find the *total* weight of one carbon dioxide molecule, we add the weight from the carbon atom and the weight from the oxygen atoms:
______________________ 12amu + ______________________ 32amu =_______________ 44amu
(answer from a) (answer from b)

Exercises: Use the information from the following table to answer questions 1-3.

Name of Atom	Chemical Symbol	Weight of One Atom (amu)
Sodium	Na	23
Chlorine	Cl	35
Oxygen	O	16
Carbon	C	12
Hydrogen	H	1

1.) When you add salt to your food, you are adding NaCl. Each NaCl molecule has one sodium atom and one chlorine atom. What is the total weight of one molecule of NaCl?
Sodium atom: 1 x 23amu = 23amu
Chlorine atoms: 1 x 35amu= 35amu
Total: 23amu+35amu=58amu
2.) When you breathe in air, your body uses oxygen (O_2). Each of these oxygen molecules has two oxygen atoms stuck together. What is the total weight of one molecule of O_2.
Oxygen atoms: 2 x 16amu = 32 amu = total
3.) Challenge Question: Your parents may use vinegar ($C_2H_4O_2$) to cook or clean. Scientist call vinegar “acetic acid.” Acetic acid has two carbon atoms, four hydrogen atoms, and two oxygen atoms. Find the total weight of one molecule of Acetic Acid.
Carbon atoms: 2 x 12amu = 24amu
Hydrogen: 4 x 1amu = 4amu
Oxygen: 2 x 16amu = 32amu
Total: 24amu + 4amu + 32amu = 60amu

Adding Integers with Charges of Atoms:

Have you ever lay in the middle of a football field? You are really small compared to the size of the field, right?

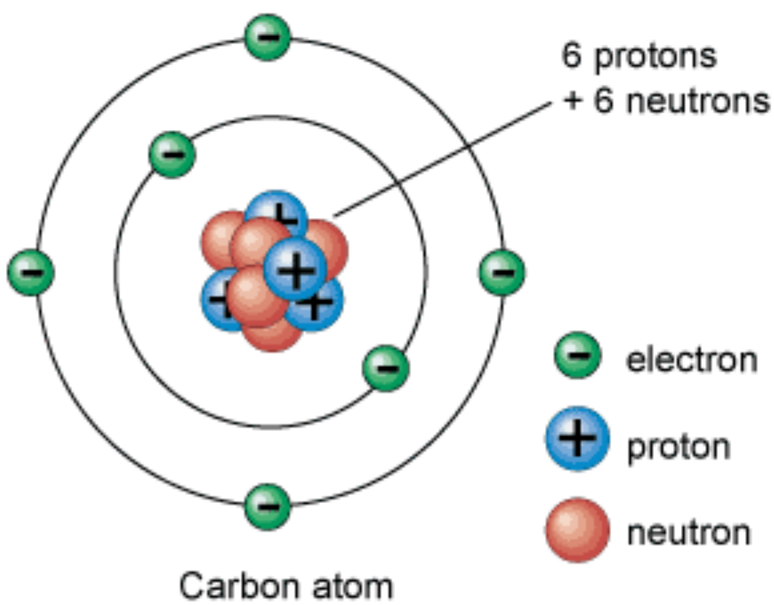
Do you remember that germs are so tiny you cannot see them; well there are things even smaller than germs. Imagine that the football field is a one of the tiniest germs; you lying in the field would be about the size of an atom.

But even atoms are made up of smaller parts called subatomic particles. There are three types of subatomic particles: protons, neutrons, or electrons. Protons have a +1 charge. Neutrons have 0 charge. Electrons have a -1 charge. The protons and the neutrons are in the middle of the atom. The electrons move around them.

Check your understanding:

1.) What is the charge of a proton? ____________________
2.) What is the charge of an electron? _________________
3.) What is the charge of a neutron? ___________________

In the diagram of an atom below, you can see that neutrons and protons are in the middle and the electrons are around the outside:



In the diagram above, you can see that if we wanted to take one of the subatomic particles (protons, neutron, or electron), it would be easiest to take an electron since they are on the outside. Indeed, when atoms "stick together" they do so because of the electrons to form bonds.

In the diagram, you can see that there are 6 electrons and 6 protons
6 electrons mean that there are 6 charges of -1. Therefore, the charge due to electrons is 6 x (-1)=-6
6 protons mean that there are 6 charges of +1. Therefore the charge due to electrons is 6 x (+1)=+6

To find the overall charge, you add the charge from electrons and the charge from protons: (-6) + (+6) = 0

Questions:

1.) What is the charge of an atom with 5 electrons and 6 protons?
    a.) Charge due to protons: ______ x ______ = _________
    b.) Charge due to electrons: ______ x ______= ________
    c.) Overall charge: ______ + _______=__________
2.) What is the charge of an atom with 7 electrons and 6 protons?
    d.) Charge due to protons: ______ x ______ = _________
    e.) Charge due to electrons: ______ x ______= ________
    f.) Overall charge: ______ + _______=__________
3.) What is the charge of an atom with 4 electrons and 6 protons?
    g.) Charge due to protons: ______ x ______ = _________
    h.) Charge due to electrons: ______ x ______= ________
    i.) Overall charge: ______ + _______=__________
4.) What is the charge of an atom with 8 electrons and 6 protons?
    j.) Charge due to protons: ______ x ______ = _________
    k.) Charge due to electrons: ______ x ______= ________
    l.) Overall charge: ______ + _______=__________

Adding Integers with Charges of Atoms (Answer Key):

Have you ever lay in the middle of a football field? You are really small compared to the size of the field, right?

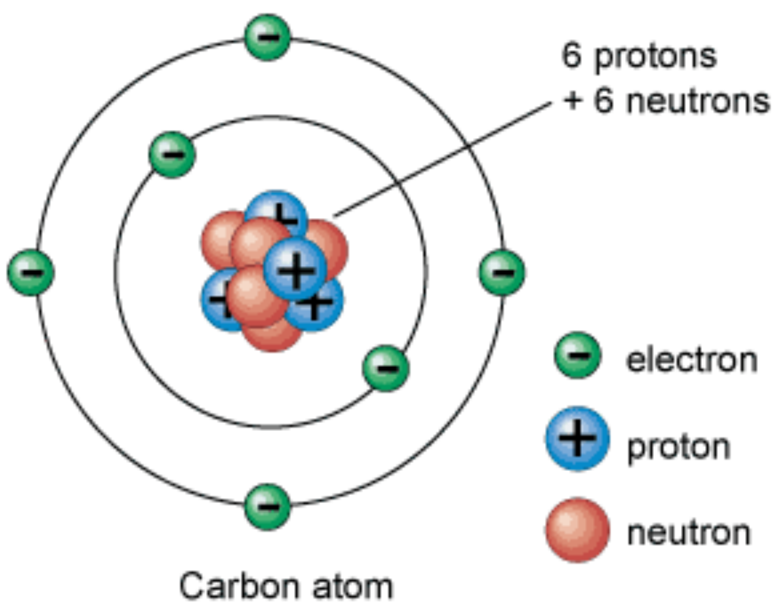
Do you remember that germs are so tiny you cannot see them; well there are things even smaller than germs. Imagine that the football field is a one of the tiniest germs; you lying in the field would be about the size of an atom.

But even atoms are made up of smaller parts called subatomic particles. There are three types of subatomic particles: protons, neutrons, or electrons. Protons have a +1 charge. Neutrons have 0 charge. Electrons have a -1 charge. The protons and the neutrons are in the middle of the atom. The electrons move around them.

Check your understanding:

4.) What is the charge of a proton? ____________________ +1
5.) What is the charge of an electron? _________________ -1
6.) What is the charge of a neutron? ___________________ 0

In the diagram of an atom below, you can see that neutrons and protons are in the middle and the electrons are around the outside:



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In the diagram, you can see that there are 6 electrons and 6 protons
6 electrons mean that there are 6 charges of -1. Therefore, the charge due to electrons is 6 x (-1)=-6
6 protons mean that there are 6 charges of +1. Therefore the charge due to electrons is 6 x (+1)=+6

To find the overall charge, you add the charge from electrons and the charge from protons: (-6) + (+6) = 0

Questions:

5.) What is the charge of an atom with 5 electrons and 6 protons?
   a.) Charge due to protons: ______ 6 x ______ +1 = _________ +6
   b.) Charge due to electrons: ______ 5 x ______-1= ________ -5
   c.) Overall charge: ______ +6 + _______ -5 =__________+1
6.) What is the charge of an atom with 7 electrons and 6 protons?
   a.) Charge due to protons: ______ 6 x ______ +1 = _________ +6
   b.) Charge due to electrons: ______ 7 x ______-1= ________ -7
   c.) Overall charge: ______ +6 + _______ -7 =__________-1
7.) What is the charge of an atom with 4 electrons and 6 protons?
   a.) Charge due to protons: ______ 6 x ______ +1 = _________ +6
   b.) Charge due to electrons: ______ 4 x ______-1= ________ -4
   c.) Overall charge: ______ +6 + _______ -4 =__________+2
8.) What is the charge of an atom with 8 electrons and 6 protons?
   a.) Charge due to protons______ 6 x ______ +1 = _________ +6
   b.) Charge due to electrons: ______ 8 x ______-1= ________ -8
   c.) Overall charge: ______ +6 + _______ -8 =__________-2

Adding Integers and Ionic Bonding
(Continued from "Adding Integers with Charges of Atoms"):

Imagine that you have a paper clip between two magnets, but one magnet is much stronger than the other. Which magnet would the paperclip move towards; the stronger magnet, right? If the paper clip was attached to one magnet, a stronger magnet could pull it away.

In chemistry the same thing happens to the **bonds** that make atoms "stick together".

For example, table salt has one sodium atom and one chloride molecule.

A sodium atom has 11 electrons and 11 protons.
What is the charge of this atom?
a.) Charge due to protons: ______ x ______ = _________
b.) Charge due to electrons: ______ x ______= ________
c.) Overall charge: ______ + _______=__________

A chlorine atom has 17 electrons and 17 protons.
What is the charge of this atom?
a.) Charge due to protons: ______ x ______ = _________
b.) Charge due to electrons: ______ x ______= ________
c.) Overall charge: ______ + _______=__________

Chlorine is a better magnet so it "steals" on proton away from sodium.
Now,
This sodium atom has 10 electrons and 11 protons.
What is the charge of this atom?
a.) Charge due to protons: ______ x ______ = _________
b.) Charge due to electrons: ______ x ______= ________
c.) Overall charge: ______ + _______=__________

This chlorine atom has 18 electrons and 17 protons.
What is the charge of this atom?
a.) Charge due to protons: ______ x ______ = _________
b.) Charge due to electrons: ______ x ______= ________
c.) Overall charge: ______ + _______=__________

Do you remember the term "opposite attract". This means that a negative charge is attracted to a positive charge (think of the attraction between opposite sides of a magnet). As you calculated above, after the chlorine steals the electron away from the sodium, the two atoms have opposite charges. That is why they stick together to form the molecules in salt!

That kind of binding is called **ionic bonding.**

Adding Integers and Ionic Bonding
(Continued from "Adding Integers with Charges of Atoms"):

Imagine that you have a paper clip between two magnets, but one magnet is much stronger than the other. Which magnet would the paperclip move towards; the stronger magnet, right? If the paper clip was attached to one magnet, a stronger magnet could pull it away.

In chemistry the same thing happens to the **bonds** that make atoms "stick together".

For example, table salt has one sodium atom and one chloride molecule.

A sodium atom has 11 electrons and 11 protons.
What is the charge of this atom?
d.) Charge due to protons: ______ 11 x ______+1 = _________ +11
e.) Charge due to electrons: ______ 11 x ______-1= _________ -11
f.) Overall charge: ______ +11 + _______ -11 =__________ 0

A chlorine atom has 17 electrons and 17 protons.
What is the charge of this atom?
d.) Charge due to protons: ______ 17 x ______+1 = _________ +17
e.) Charge due to electrons: ______ 17 x ______-1= _________ -17
f.) Overall charge: ______ +17 + _______ -17 =__________ 0

Chlorine is a better magnet so it "steals" on proton away from sodium.
Now,
This sodium atom has 10 electrons and 11 protons.
What is the charge of this atom?
g.) Charge due to protons: ______ 11 x ______+1 = _________ +11
d.) Charge due to electrons: ______ 10 x ______-1= _________ -10
e.) Overall charge: ______ +11 + _______ -10 =__________ +1

This chlorine atom has 18 electrons and 17 protons.
What is the charge of this atom?
d.) Charge due to protons: ______ 17 x ______+1 = _________ +17
e.) Charge due to electrons: ______ 18 x ______-1= _________ -18
f.) Overall charge: ______ +17 + _______ -18 =__________ -1

Do you remember the term "opposite attract". This means that a negative charge is attracted to a positive charge (think of the attraction between opposite sides of a magnet). As you calculated above, after the chlorine steals the electron away from the sodium, the two atoms have opposite charges. That is why they stick together to form the molecules in salt!

That kind of binding is called **ionic bonding.**

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