A Recipe Book for Chemical Reactions

Amanda Reasoner

Objectives and Rationale

According to the OECD, The Organisation for Economic Cooperation and Development, the United States science education ranked nearly thirtieth in the world in 2009. The US was topped by obvious educational powerhouses, such as China, but also by countries such as Latvia, Slovenia, Singapore and many others[1] (OECD). At a time where our students seem to have more access to technology and information than ever before, we seem to slip further and further down the ranks in regards to how well prepared our students are for the twenty-first century. It is important that our students leave school knowledgeable about science and technology. Students should leave school prepared to compete globally in all areas. It is no longer appropriate for students to demonstrate mastery in only reading and math. Fundamental knowledge of the sciences and scientific literacy are vital skills that schools must emphasize if we are to prepare our students for their futures.

My unit will focus on chemical reactions in chemistry. While chemistry truly surrounds us and our students everyday, most are intimidated by it and tend to believe that it is too complicated for them. It is imperative that students realize they are very familiar with chemistry and it is not this “thing” that they can just avoid and not have to learn. I often ask my students if they have used bleach while cleaning. Of course, most have. I then ask them to list off some of the things they know they need to be careful of while using bleach. Most are aware that it will permanently damage their clothes, that they should be careful not to get it on their skin and that they should never mix it with other cleaning supplies. I then tell them how smart they are and explain that they must have already taken chemistry!

In regards to chemical reactions, the material can be somewhat challenging simply because of the abstractness of the idea. For some students, reading a chemical reaction on paper is enough for them to grasp the abstract idea that in a chemical reaction, atoms rearrange and form new chemical bonds and completely new substances. In middle school, however, this is sometimes too abstract for students to wrap their brains around. My past experience has been that students are intrigued by chemical reactions, but sort of miss the big idea. My challenge has always been to get kids to see beyond the bubbles or the "cool things" that happen when they watch a chemical reaction and really think about what is occurring. If a student truly understood what a chemical reaction was, then they could see the benefits of learning chemistry. What an amazing concept that you could take two seemingly useless things, combine them and make a product that is now useful to many. Because I want my students to see the usefulness of chemistry, this unit will focus on using chemical reactions to create products that they have actually seen and are familiar with in their lives. Mixing vinegar and baking soda is always fun, but when students see the remaining liquid in the beaker after the reaction, they have no clue that it is chemically different from the starting reactants, because they have no idea what the product is. However, if they could take a few chemicals and make soap, a substance they are all clearly familiar with, it would be obvious to them that the product was in no way like the reactants.

What I hope to address in my unit is the usefulness of chemical reactions and the concept that the product is a completely new substance than before. In the end, my goal is for students to appreciate the predictability of chemical reactions, not just how fun they are to watch. I want students to be able to see the usefulness of chemistry and all science as a way of improving our lives.

School Demographics

To understand the strategies used in my unit, it may be helpful to understand the demographics of my school. I teach 8th grade science in an urban setting in Charlotte, NC. More than ninety percent of my school is economically disadvantaged and a major challenge to teaching science is that nearly half of the school is not able to read on grade level. While my students are mildly interested in science, many are lacking general exposure to what most would consider common information and experiences of children. Due to these factors, I rely heavily on hands-on activities so that kids have a chance to create new experiences that allow them to build on.

Background Information

Matter is defined as anything that has mass and takes up space. All matter is made of atoms, and for this reason, atoms are generally defined as the building blocks of matter. The idea that matter must be made of smaller units that combine in different arrangements is an ancient one, generally credited to Greek philosophers. It was Greek philosophers that believed that all things could be broken down into smaller units, or "elements", of which they believed there were only four: fire, earth, air and water[2].

Obviously, this is no longer supported by any scientific evidence, but the premise that matter can be understood better by learning about the smaller units that comprise matter is the foundation of chemistry. The smaller units that matter can be broken down to are, of course, atoms. Ironically, no one has ever actually seen an atom, but through years of deductive research, we do have a basic model that is supported by the work of both chemists and physicists alike.

Structure of the Atom

Atoms are made up of three sub-atomic particles: protons, neutrons and electrons. Protons and neutrons are both located in the center of the atom, or the nucleus. Outside the nucleus is the electron cloud, where the electrons are constantly in orbit. Electrons are arranged in energy levels, called orbitals. Because this unit is being written for middle school students that are currently performing below grade level, the explanation of energy levels and the electron configurations will be kept very basic. Of course, if this were being used for a high school course, it would be necessary to go into more depth.

Protons are positively charged and electrons are negatively charged. Neutrons have no charge and therefore only add mass to the atom, and do not affect any other properties. It is the number of protons in an atom that determines what type of element it is. For example, any atom that has seventy-nine protons is gold, regardless of how many electrons or neutrons are present in the atom. It is the electrons that then determine how an atom will interact or bond to other atoms.

Why Do Atoms Form Bonds?

As stated above, it is the electrons that determine the types of bonds that an atom will form. In their neutral state, atoms start off with an equal number of protons and electrons. Take carbon for example: carbon has six protons, so therefore, it starts with six electrons. The electrons that surround an atom are arranged into orbitals, each with a set capacity for how many electrons it can hold before it is filled. The first orbital can hold two electrons, the second can hold eight electrons, the third can hold eighteen electrons and the fourth, thirty-two[3]. So, sticking with our example of carbon, a carbon atom would have two electrons in its first orbital and four in its second orbital. According the octet rule, atoms are most stable with eight electrons in their valence shells. In an effort to become stable, atoms will gain, share or lose electrons in order to obtain eight electrons in their valence shell. This, of course, is an oversimplification of atomic bonding, since the unit is based more on chemical reactions than the explanation for chemical bonding.

Chemical Reactions

When atoms form bonds or break bonds, a chemical reaction has occurred. The new combination of atoms, referred to as the product, has completely different properties than the original atoms or compounds, called the reactants. The following is the chemical reaction in which water is made:

$$H_2 + O_2 \rightarrow H_2O$$

When first showing chemical reactions to students, I do not complicate things by showing the balanced chemical equations. With the above equation, I am simply trying to familiarize them with the idea that two substances they are familiar with combine to form a new substance, they are also familiar with. Of course, the balanced equation would be:

$$2H_2 + O_2 \rightarrow 2H_2O$$

The substances to the left of the arrow are the reactants and to the right of the arrow are the products. When a chemical reaction occurs, one can obviously not see the atoms themselves rearrange. However, there are clues or signs that a new substance has been made, indicating that a chemical reaction has occurred. Some of the possible indicators of a chemical reaction are the presence of bubbles, which shows that a gas has been produced, a temperature change, a color change or the formation of a precipitate, which is a solid that forms when two liquids are combined[4].

Chemical Changes vs. Physical Changes

Physical changes describe changes in matter that do not involve making new chemical bonds. After a physical change, the chemical formula of the substance that is changing will still be the same. For example, when an ice cube melts into water, the chemical formula, H_2O, remains the same. Some examples of physical changes include making mixtures, changing the shape of an object, breaking something into smaller pieces or changing the volume of a substance.

When chemical bonds between atoms are formed, this causes a completely new chemical to form. The new substance that is formed is completely different than the original substances. When a new substance is formed with new chemical properties, this is an example of a chemical change[5]. As mentioned above, it is impossible to actually see the atoms break bonds and form new ones. There are, however, observable signs that indicate that a chemical change has occurred. These signs include a color change, a temperature change, bubbles, which indicate that a gas was produced in the reaction, and the formation of a precipitate. A precipitate is a solid that forms when two liquids are combined. Additionally, odor changes and the release of light energy can indicate that a chemical change has occurred[6].

The Law of Conservation of Matter

When it comes to the law of conservation of matter, I usually emphasize that while chemistry is cool, it is not magic. According to the law of conservation of matter, matter can neither be created nor destroyed. Essentially, this means that atoms themselves cannot be created or destroyed. In a chemical reaction, whatever atoms are present at the beginning of a reaction, must also be present in the products of the reaction. There are times when the products of some reactions may appear to have less mass than before, as in the case of burning wood. This is simply not possible. The only difference between the reactants and products, then, is the arrangement of the chemical bonds between atoms, not the atoms themselves. Below is the chemical equation for the reaction that forms rust.

$4Fe + 3O_2 \text{--->} 2Fe_2O_3$

In the reaction, there are four iron atoms on the reactant side and four on the product side. There are six oxygen atoms on the reactant side and six on the product side. Another way that the law of conservation of matter can be demonstrated is by using the actual mass of the reactants and products. Below is the chemical reaction that occurs when vinegar and baking soda are combined.

$CH_3COOH + NaHCO_3 \rightarrow H_2O + NaOCOCH_3 + CO_2$

If you were to begin by mixing 5 grams of baking soda and 5 grams of vinegar, then according to the law of conservation of matter, the mass of the products has be a total of 10 grams. If this reaction occurred in an open system, such as a beaker or a cup, it may appear that the products actually have less mass than the mass of the reactants. This is because the carbon dioxide, which is responsible for the bubbles that make this experiment so much fun for students to watch, has been released into the air. However, if this reaction occurred in a closed system, such as a ziploc bag, the mass of the reactants and products would be the same.

$CH_3COOH + NaHCO_3 \rightarrow H_2O + NaOCOCH_3 + CO_2$

5 grams 5 grams all products combined must have a mass equal to 10 grams

While understanding the law of conservation of matter is the foundation for learning to balance chemical equations, middle school students in North Carolina are not required to learn how to balance chemical equations. Therefore, none of this curriculum unit will focus on learning how to balance chemical equations.

Strategies

Cooperative Learning

The science classroom is one of the easiest places to make use of cooperative learning. Studies have shown that students do best when they have the opportunity to talk about their learning, disagree about ideas and entertain other peoples' viewpoints and ideas[7]. In the proposed unit, most activities are intended to be done in lab groups. The unit includes several labs, including one where students must work together and justify their decision for labeling changes as physical or chemical changes.

Foldables

In my past experience, students love to make foldables, which always makes things easier for teachers! It is great for students because they provide student-made study guides and they allow for some creativity while providing structure to the assignment. One of the biggest advantages is that they provide students the opportunity to take ownership in their work[8].

Manipulatives

In this unit, students will use manipulatives in the form of legos to model the law of conservation of matter. Manipulatives allow students to improve their language and verbalization of their thinking. Generally, the use of concrete models increases understanding and helps move to comprehension of the abstract[9]

Labs

I am not sure that it would be possible to do a curriculum unit on chemical reactions without labs and experiments. Labs offer an opportunity for students to learn in a hands-on, exciting way. Studies have shown that neural connections form more readily when students are the ones doing an activity than when the teacher is doing an activity or lab with the students watching[10]. In this unit, students will have lab activities in which they compare physical changes to chemical changes, use electrolysis to separate water in hydrogen and oxygen and make both soap and nylon.

Activities

Starting the Unit:

I will start off the unit by mixing together the ingredients to make cupcakes. Students will watch as I mix together the eggs, the cake mix and milk. While mixing the ingredients we will discuss whether or not students would like to have some of the cake batter as dessert. Why or why not? On the board, I will list the starting ingredients and introduce the word reactants. Then, I will already have cupcakes made for the students to enjoy for our "Introduction to Chemical Reactions Party." The cupcakes will be our products and we will discuss how our products are different than our reactants. Students will create a booklet that will be our "Chemical Reactions Recipe Book" and our first recipe will be for cupcakes. Some questions that could be asked to get students to start thinking about the law of conservation of matter are:

1. Would it be possible to get strawberry cupcakes if I did not put strawberries in the batter?

2. Would it be possible for me to put chocolate chips in the batter and then not find any chocolate in the cupcakes?

3. What makes baked cupcakes take up more room than the original batter?

The Law of Conservation of Matter-Legos

This activity would be appropriate after covering material on chemical bonds and the octet rule. Students will be given Ziploc baggies with legos in them. Below is an example of how this activity can be used to model the law of conservation of mass.

Students start with three blue legos, two green legos and 4 red legos. Instruct students to build each of the following combinations with their legos:

1. 2 blues + 1 green
2. 4 reds +2 greens + 3 blues

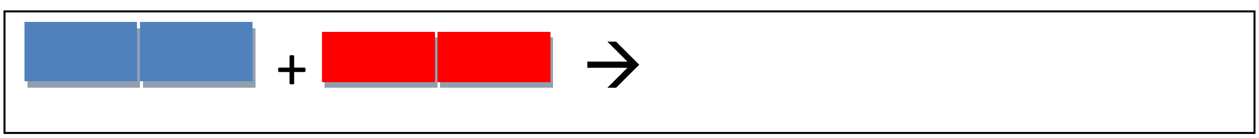
3. 2 greens + 1 blue + 2 reds
4. 1 green + 1 blue + 1 pink ???

Of course, students will look at you like you are crazy, since they did not have a pink. Ask students if it is ever possible to end up with a "building block" that was not already there? Of course not!

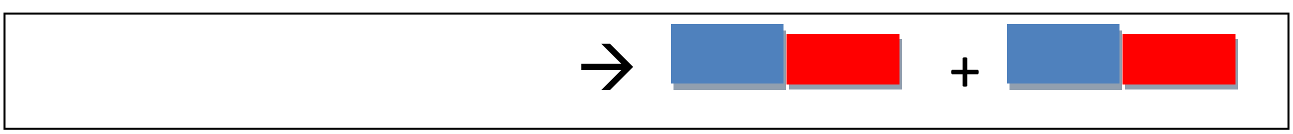
For the next demonstration, students will see how the mass of the legos you start with never changes, regardless of how they are connected. In this activity, it will work best if students use an electronic balance. If you do not have an electronic balance, then assign arbitrary masses to the legos.

Have kids connect two blue legos and find their mass. Then have the kids separate the two blue legos and find the mass of both legos together, but not attached to one another. Whether the two blue legos are attached or not, they should have the same combined mass. If the two blue legos that were bonded (attached to each other) represented a chemical reaction, what would the chemical formula for the reactants be? If the two separated blue legos were the products, what would the chemical formula for the products be? (The reactants should be $Blue_2$ and the products would be blue + blue, or 2blue.)

Next, have students connect two blues and then two reds.



Have them find the mass of the two blues and two reds. See if students can write a chemical formula for their reactants. Then have students rearrange their reactants to form the products shown below.



See if students can predict the mass of the products, then have them weigh the products (They should weigh both of the products, since the law of conservation of matter says that the total mass of the reactants always equals the total mass of the products.) They should see that the mass of the reactants must always be the same as the total mass of the products, since all that is happening in a chemical reaction is that atoms are rearranging and forming new bonds to atoms that were already present.

This activity can be repeated numerous ways depending on the needs of your students. After students grasp the basics using tangible objects, like legos, the next logical step would be to transition into applying the law of conservation of matter to actual chemical equations. Students should now be able to count atoms on the reactant and product side to determine if equations are written according to the law of conservation of matter.

In the eighth grade, students are not expected to be able to balance chemical equations. They are only expected to be able to tell if equations are written according the law of conservation of matter and use it to predict the mass of compounds in reactants or products. In a higher level classroom or in high school, this could easily be used as a quick introduction for how to balance equations and why it is necessary. This activity could also be extended upon and could be used to introduce the concept of a balanced chemical equation. Students could be asked to balance the "lego" equation by finding a way to get the same number of each type of lego on both sides.

Writing Chemical Reactions- Water Electrolysis Lab

In order to learn how to write a chemical reaction, we will start with hydrolysis. Again, the emphasis of this unit will be to teach about chemical reactions using materials students are familiar with. Depending on the level of the students, students can complete the hydrolysis lab on their own or it can be done as a demonstration. We will start with a beaker of water. Students should be able to give the chemical formula for water at this point. In their Chemical Reaction Cookbook, students will list water on the reactant side of the page. Have students list some of the properties of water. Be sure to point out the obvious if they do not: water is a clear liquid at room temperature, it has a density of 1 g/mL, etc. Ask students what two elements water can be broken down into. Using the proposed apparatus, students will perform the decomposition of water reaction (or watch the teacher perform the reaction). At the middle school level, I would not mention the addition of salt to the water, so that you can keep it as simple as possible. After conducting the reaction, allow students to observe what has collected in the test tube and see what they think could possibly be in the test tubes. This is a good time to remind them about the law of conservation of matter. Ask students if they think it could be Neon or some other gas? Why or why not? Students will then write their products, oxygen + hydrogen on the right hand side of their cookbook. Underneath where they have written the names of the reactants and products, have students also write out the chemical formulas for each. Students can start with the unbalanced chemical reaction:

$$H_2 + O_2 \rightarrow H_2O$$

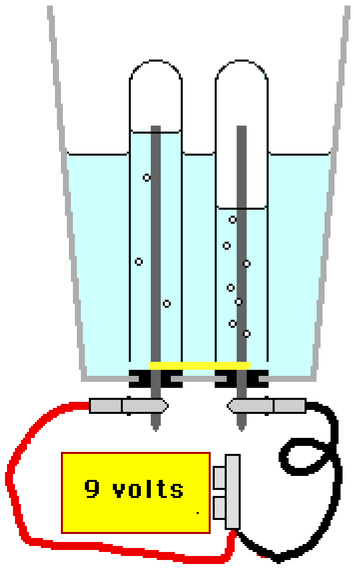
Then, prompt students to tell you what is wrong with the equation. If there are two oxygen atoms on the reactant side, there have to be two on the product side. The equation is not written according to the law of conservation of matter. Then, you can have students write the balanced form of the equation:

$$2H_2 + O_2 \rightarrow 2H_2O$$

After students have watched the formation of hydrogen gas and oxygen gas, discuss the properties of the two gases. Question students to see if they know any properties of hydrogen and oxygen, emphasizing that the elements have very different properties than the compounds they combine to form. This activity will be followed up with practice identifying reactants and products of reactions and counting the elements found in provided reactions to see if they follow the law of conservation of matter.

Procedure for Water Electrolysis Lab

1. Fill a 400 ml beaker about ¾ full of distilled water.
2. Dissolve a small amount of table salt in the water, approximately half a teaspoon. (Again, I would not tell the kids I had added salt, since the point of this lab is to make chemical reactions very simple. If it was a high school class, you might be able to explain the purpose of the salt.)
3. Hang two j- shaped pieces of copper off the side of the beaker into the water so that about 1 inch of copper sticks up from the bottom of the beaker.
4. Fill two test tubes with distilled water. Using your thumb as a stopper, invert the test tubes one at a time and place them upside down in the beaker of water. Once the opening of the test tubes is submerged, you may remove your finger. This is so no air bubbles get into the test tube.
5. Next, place the test tubes over the each of the copper wires in the water.
6. Connect one copper wire to the positive terminal of a 9 volt battery using alligator clips.
7. Connect a copper wire to the negative terminal of the battery using another alligator clip.
8. Now, students should observe what is happening around the copper wire inside the water. As the water is broken down into oxygen and hydrogen gas, the water in the test tubes will be displaced as the gases rise to the top of the test tubes since they are less dense.



This picture shows a possible apparatus for electrolysis of water[11]. However, in the experiment description above, the test tubes are suspended into the beaker with the use of j-shaped copper wire which wraps around the edge of the beaker and then into the test tubes.

Chemical Reaction or Not

This section of the unit will begin with learning how to identify the difference between simply a physical change and a chemical change. Students will start by creating a foldable on the four indicators of chemical changes and the differences between physical and chemical changes. To practice determining if changes in matter are chemical changes or physical changes, students will complete a lab in stations. Each station will be a change in matter and students will have to label each change as physical or chemical and then justify their answers. If stations are not practical for your class sizes or the level of your students, these labs can be done by the teacher as demonstrations.

Here is a list of possible stations that can be used, depending on available supplies:

1. baking soda and vinegar- chemical

2. copper sulfate and aluminum foil- chemical- Place a small piece of folded up aluminum foil in a small beaker of water and add approximately half of a teaspoon of copper sulfate to the water. This is a great one for students to be able to see the formation of a precipitate. Cooper sulfate is inexpensive and easy to order from any science supply company.
3. Mix Kool-Aid powder and water- physical
4. Boil water- physical
5. Antacid and water – chemical- This is best to do in a Ziploc baggie. Encourage kids to feel the bag during the reaction so they can feel how cold the bag becomes.
6. Mix salt and water- physical
7. Melt and ice cube- physical
8. Sucrose and molten potassium chlorate- chemical- This one is hard to do if you are in a typical middle school classroom with no fume hood. However, there is a great video on teacher tube that is just as exciting for the kids. This video can be accessed at: http://www.teachertube.com/viewVideo.php?title=Screaming_Gummy_Bear&video_id=58172 [12].

Using Chemical Reactions to Make Usable Products

Now that students have some idea about how to tell if a chemical reaction has happened, we will add to our recipe book to see how some common materials are made and how they can make them as well. We will relate this back to the cupcakes and how chemical reactions occur when we cook our food. I will show students a variety of things they use everyday that are the result of chemical reactions. Some possible examples are any type of plastic, clothes made with synthetic fibers, aspirin and soap. I will then tell students that they will be able to make some of those products through chemical reactions.

We will start by watching a clip about how nylon is made, called "Fabricating Fabric: Profile of Nylon"[13].

Students will then make nylon using a solution made from a sebacoyl chloride and heptane solution made from diaminohexane and water. Students will write the "recipe" using their chemical reaction cookbook. They will describe the properties of the reactants and the products. In order to complete this lab, I will use the kit from Carolina Biological Supply[14].

Making Soap

The next “recipe” in the students’ recipe book will be for making soap. The teacher procedures are enough for the experiment to be repeated fifty times. The procedure below was adapted from juliantrubin.com[15]

Procedure for Teacher:

1. Prepare sodium hydroxide and alcohol solution. Measure 120g of sodium hydroxide (lye) and place it in a beaker. Pour in enough water to make a 500 mL solution and stir until the lye is dissolved. Add 500 ml 70% isopropyl alcohol. Be sure to wear safety goggles.

2. Prepare fat: Solids such as Crisco work best. Melt approximately 1 kg of Crisco or another vegetable shortening. Heat fat to 40 to 45 degrees C, until it is a liquid.

Materials

Container with at least 100g of either table salt or kosher salt.
Balance scale.
Heating tray or electric burner.
20ml of sodium hydroxide/alcohol solution
20ml of melted fat or oil.
Soup can
Glass custard cup or container to fit into the mouth of the soup can
Safety goggles and aprons.
Wooden stirrers.
Two aluminum pie plates, inverted and stapled
Cheese cloth.
Small cup (4 oz.) ice water.

Student Procedures

1. Measure out 20 mL of the sodium hydroxide and alcohol solution.

2. Measure out 20 mL of melted fat.

3. Add fat to custard cup. Place on water bath.

4. Pour sodium hydroxide/alcohol solution into fat while stirring with wooden stick.

5. Continue heating and stirring until a small sample can be completely dissolved in a test tube filled half way with water.

6. While stirring the solution have another student weigh 90g of salt into a container, using a balance scale.

7. Dissolve salt in 300ml of water.

8. Pour the soap solution directly into the salt water. The soap will separate and float.

9. Using a rubber band place cheesecloth over another jar. Pour the salt solution and soap through the cheesecloth. Allow solution to drain. Pour 4 oz. of ice water on soap to remove the salt.

10. Gently squeeze excess water from the cloth. Spread out the cheese cloth to allow the soap to dry. Some soap will dry faster than others, allow 1 to 3 days.

11. Wash hands with soap and water. Avoid contact with eyes.

Conclusion

I never had the privilege of being exposed to chemistry in middle school. When I was finally introduced to chemistry in high school, I was so fearful of it, that I had already told myself that it was too hard for me. In the nature of most self-fulfilling prophecies, I did not do so well in class. It was never taught in a way that made it relevant to my everyday life, when in all honesty, it is such an easy thing to relate to everyday. I hope that by the end of this unit, my eight graders are not fearful of chemistry. Instead, I want them to be excited by chemistry, to understand the benefits of learning chemistry and to see how it improves their everyday lives.

Appendix: Implementing District Standards

4.06 Describe and measure quantities related to chemical/physical changes within a system:

- **Temperature.**
- **Mass.**
- **Precipitate.**
- **Gas production**.

In the proposed unit, students will have to determine whether changes in matter are physical or chemical. They will be able to use the indicators of a chemical reaction (temperature change, bubbles, color change and formation of a precipitate) to determine if examples of changes in matter are physical or chemical.

4.07 Identify evidence supporting the law of conservation of matter.

- **During an ordinary chemical reaction matter cannot be created or destroyed.**
- **In a chemical reaction, the total mass of the reactants equals the total mass of the products mass of the products.**

This unit will cover the law of conservation of matter by first having students use legos as manipulatives in order to represent bonding between atoms. Students will see that no matter how they rearrange the legos they began with, the total ending mass of their legos is always the same. Students will then apply this to a lab in which they separate water into hydrogen and oxygen through electrolysis.

Bibliography for Teachers

AIMS Educational Foundation, *Chemistry Matters* (Fresno: AIMS Education Foundation, 2003). This book has some amazing experiments related to the law of conservation of matter and chemical reactions. Everything is simple and the reproducibles are very kid-friendly.

Bill Robertson, *Stop Faking It: Chemistry Basics (*Arlington: NSTA Press, 2007). This book is great for teachers that are teaching chemistry for the first time, that have not taught it in a while or that just want a great review of the basics of chemistry. It has great mini-labs that can be done in the classroom.

Cathy Cobb and Monty L. Fetterolf, *The Joy of Chemistry: The Amazing Science of Everyday Things* (Amherst: Prometheus Books, 2005). This is a great book with lots of background information for any chemistry teacher. It also contains neat labs that can be done in the classroom.

"Middle School Chemistry" American Chemical Society. http://www.middleschoolchemistry.com/ (accessed November 28, 2011). This is a link sponsored by the American Chemical Society. You can download all of their lessons for free and there are great lessons for chemical bonding and chemical changes.

Reading List for Students

Larry Gonick and Craig Criddle, *The Cartoon Guide to Chemistry* (New York: Collins Reference, 2005) This is a great book for both teachers and students. It covers some of the basics of chemistry through cartoons.

Robert E. Wells, *What's Smaller Than a Pygmy Shrew*?(Morton Grove: Albert Whitman and Company, 1995). This is a great book to start off talking about atoms. It helps students understand how relative the word small is and how small atoms really are.

"Science for kids" American Chemical Society. http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_TRANSITIONMAIN&node_id=878&use_sec=false&sec_url_var=region1&__uuid=e367f9b1-7ff2-4f62-bf4d-70a92b383b97 This is a great on-line resource for kids that could be used at home or in the classroom. It would be great for a computer station.

Notes

---

[1] "OECD", accessed December 4, 2011. http://www.oecd.org/document/0,3746,en_2649_201185_46462759_1_1_1_1,00.html

[2] Bill Robertson, *Stop Faking It: Chemistry Basics (*Arlington: NSTA Press, 2007), 5.

[3] Cathy Cobb and Monty L. Fetterolf, *The Joy of Chemistry: The Amazing Science of Everyday Things* (Amherst: Prometheus Books, 2005), 63.

[4] "Chemical Changes." Rhode Island College, accessed December 4, 2011. http://www.ric.edu/faculty/ptiskus/chemical/

[5] Darlene R. Stille, *Atoms and Molecules* (Minneapolis: Compass Pointe Books, 2007), 29.

[6] "Chemical Changes."

[7] Marcia L. Tate, *Worksheets Don't Grow Dendrites* (Thousand Oaks: Corwin, 2010), 93.

[8] Dinah Zike, *Big Book of Science* (San Antonio: Dinah-Might Adventures, LP, 2001), 2.

[9] Tate, *Dendrites*, 56.

[10] Ibid, 56.

[11] "Electrolysis of Water", accessed December 5, 2011. http://www.science-projects.com/Electrolysis/eLysis.htm

[12] "Screaming Gummy Bears." Teacher Tube, accessed December 5, 2011. http://www.teachertube.com/viewVideo.php?title=Screaming_Gummy_Bear&video_id=58172

[13] "Fabricating Fabric: Profile of Nylon." NBC-Learn, accessed December 5, 2011. http://www.nbclearn.com/portal/site/learn/chemistry-now/chemistry-of-nylon

[14] http://www.carolina.com/product/physical+science/chemistry/chemistry+kits/nylon+synthesis+demo+chemistry+kit.do?sortby=ourPicks This is the website for ordering the nylon making kit.

[15] “Making Soap”, accessed December 4, 2011.
http://www.juliantrubin.com/encyclopedia/chemistry/soap_experiments.html