Easy to Prepare, Easy to Do, Easy to Clean Up, Not Much Chance to Make Mistakes

Kitchen Chemistry

By Alice Rysdon

Contents of Curriculum Unit

Overview

This unit teaches middle school students that have varying amounts of previous knowledge about chemistry. This unit is meant to serve as an introduction to students' understanding of chemistry. It was designed to be a fun, activity-driven group of lessons that do not require a large amount of scientific equipment. They do require access to water and a sink would be useful for cleanup. Using materials that are easy to obtain and not conducive to misuse by students, scientific experiments and demonstrations are conducted that help students to understand chemistry on a more concrete level.

Rationale

Many of the materials that are used in the kitchen and around the house can also be used to demonstrate scientific principles and concepts, especially in relation to chemistry. With the idea that chemistry can be dangerous and that there are some students that need to have very safe experiments and demonstrations while also having fun experiments from which they can learn, this unit was started. It is designed for an eighth grade class of diverse abilities and backgrounds, some of the students might be functioning at an eighth grade level, while others are as much as 5-6 years below grade level in their reading ability. This unit emphasizes basic ideas and principles of chemistry and science. By having demonstrations and hands on activities, I hope to make scientific experiments and the scientific method more concrete for students, and hopefully more memorable as well. All students can participate in predicting what will happen in an experiment, and making a chart or other written record of their results. Some of the concepts have several different experiments that lead into each other or reinforce one another. Some emphasis was given to some concepts that are particularly abstract and therefore benefit from being made more concrete.

Many books have short, quick experiments to further students' understanding of science and chemistry using only basic equipment and materials found around the house. Many of these books are listed as student resources. However it should be noted that the books can serve as a useful tools for the teacher also. Frequently a teacher may find the right demonstration or experiment to introduce various science concepts and ideas. I urge teachers to peruse these books to find more ways to demonstrate chemistry concepts.

Chemistry has many different parts and it was difficult to decide what knowledge to present to the students. All matter is made up of atoms that then form molecules. An atom is the smallest substance that cannot be broken down more with chemical means. Atoms have a nucleus or center made up of protons (with positive charges) and neutrons (with no charge). Around the nucleus of an atom are its electrons(which have negative charges). The electrons are organized into shells. The first shell can contain 2 electrons, the other shells can each contain 8 electrons. Every atom has the same number of protons and electrons. Each inner shell is filled with electrons before the next shell gets electrons. When an atom's outer shell contains fewer electrons than its maximum, that atom will tend to form bonds with other atoms to complete its outer shell with shared electrons. Therefore, water or H_2O, containing 2 hydrogen atoms and 1 oxygen atom, has the 2 hydrogen atoms, each of which has only 1 electron in its 2 electron outer shell balanced by oxygen which has 6 electrons in its 8 electron outer shell.
Chemists organize the different elements in the periodic table. The periodic table seems to fascinate some students. When they come across it, they might feel that it contains a lot of information, which it does. Students also need to have a list of the symbols of the elements, so they can know which element each symbol stands for. Mostly, this will be used for a more advanced class. However, some familiarity with the period table seems desirable. Each box in the periodic table contains the symbol of an element, its name, its atomic number, its atomic weight and the number of electrons in each energy level of that atom. Families of elements make up the vertical columns of the periodic table. The elements in a family contain the same number of electrons in their outer shell. Since they contain the same number of electrons in their outer shell, they also share many of the same chemical properties, and will tend to combine with the same elements or families of elements.

Molecules can be polar or nonpolar. Polar molecules tend to stick together. Nonpolar molecules stick together. Polar molecules have a negative charge on one end and a positive charge on the other end. Nonpolar molecules do not have charges. The reason that detergent is able to clean is that it is a very long molecule which has a polar end and a nonpolar end. The nonpolar end can grab onto oil, or other soiled substances on clothes. When the polar end of the detergent then grabs onto a polar molecule, the dirt can be washed away.
Viscosity and density are two concepts that are difficult to describe adequately so it is especially good to have them demonstrated. Viscosity refers to the 'thickness' of a liquid or its rate of flow when poured. Density refers not just to weight, but also to the area the weight occupies. Density is not usually thought of when thinking about liquids although liquids also vary in density. The fact that cold water sinks because it is more dense than warmer water affects our oceans and many other dynamic systems in the world. When an object sinks, it sinks because the amount of water it displaces weighs less than it does. When an object floats, it displaces the equivalent of its weight in water. Therefore, if you have a block of foam that weighs 2 ounces, it will sink until the part of it that is below water takes up the same room as 2 ounces of water would.
Acids and bases can also be introduced to students. Acids are sour tasting and react with metals to give off hydrogen gas. Students can be told that they have tasted lemons which are acidic. Bases taste bitter and feel slippery. Soaps are bases which is why they feel slippery. Students need to know that many acids and bases are dangerous to handle, so chemists never taste to

check whether a substance is an acid or a base. Chemists instead rely on an indicator which is a dye that reacts when in contact with an acid or a base. There are many different indicators for bases and acids.

Objectives

Students will gain more familiarity with the Scientific Method, designing and developing experiments. Students will learn about carrying out an investigation, listing and gathering materials, setting up and carrying out procedures with controls and variables, and constructing data sheets, graphs, and charts. Students will understand through demonstrations and experiments how scientific principles of chemical phenomena have developed and gain an understanding of how this helps us in everyday life.

Strategies

Whenever possible hands on activities are used to describe phenomena. Some demonstrations and experiments are very simple, others are more involved. Students are asked to make charts and to write results. Sometimes students are asked to write a narrative description of a demonstration. One demonstration can be used to show students what analytic chemists do. Students can then use it to demonstrate to other classes, other teachers, or the principal, so that they have experience finding within a limited sphere what ingredients are in a clear liquid.

Classroom Activities

Investigating Polar and Nonpolar liquids

Molecules are either polar or nonpolar. One can do a number of different experiments around this fact. You cannot make a mixture of only oil and water. This fact can be illustrated in 2 ways.

Oil and water don't mix

First, the student can pour water into a glass and pour oil into the glass on top of the water. If the student pours too vigorously, in a minute or two the water sinks to the bottom and the oil rises to the top. The student then puts a few drops of food coloring on top of the oil. At this point, the student takes a fork and pushes down on the various food colors As the food coloring gets into the water, it will mix with the water.

Oil and water don't mix 2

Another illustration of this same principal, not too different, is to have the student pour water in a glass. Next the student mixes food coloring with oil. The student carefully pours the oil on top of the water. As the oil molecules of each drop move around the food coloring molecules come in contact with the water and bloom out their color.

Oil and water and detergent

Students at this point will have a very good idea about oil and water not mixing. Have them put oil and water together in a jar, put the lid on, and shake it up. Briefly, you can get the oil and water to mix. Ask students to predict what will happen when you let it stand. Students will probably predict correctly that the oil and water will separate. Now ask students what will happen when you add detergent to the oil and water mixture before you shake it up. Because the detergent has a polar end to latch onto the water and a nonpolar end that will hook onto the oil, the detergent prevents the mixture from separating. This is why we use detergents to clean away grease and oil.

Viscosity of Liquids

Viscosity is a good example of what can be defined, but does not seem to have reality for many students without a clear demonstration. Viscosity is a measure of how easily a liquid flows. A liquid that does not flow easily has a high viscosity and a liquid that flows easily has a low viscosity.

For this demonstration of viscosity, one uses 4 bottles with a marble in them and a liquid. The 4 liquids recommended are: water, honey, roll-on anti-persperant, and hair gel. The students can prepare each bottle with the one of the liquids and a marble, turning the bottles over, the students observe how long each of the marbles takes to get to the bottom of their jar.

Letting students do this in small groups of two or three seems ideal. Students should have a chart prepared to take down what has happened and the time each marble takes to reach the bottom. They should have space to write down multiple results. To begin to get the idea that experiments are done a few times to check results, the students in a group could each take a turn turning over the jars, timing them, and writing down the results.

Density, Solids, and Why Boats Float

Household Density Column

To illustrate different densities in liquids, one can pour each of several liquids of varying densities into a glass cylinder. As long as they don't mix as you pour them in carefully, they will stay distinctly separate. One good way to do this is to make funnels from paper and use them to pour liquid, having the funnel direct the liquid to the side of the cylinder, just above the liquid already in the cylinder. The liquids need to be poured slowly in the following order: Dark Karo syrup or maple syrup, Glycerin, Dawn dishwashing liquid, water, vegetable oil, rubbing alcohol..

This activity can be extending by dropping solids in and seeing where they end up, at the bottom, the top, or floating between layers. Let students handle the various items to be put in and make predictions of what they think will happen with each one. If you have the students make a prediction immediately before you put each item it, perhaps as students get more feedback, they will make better predictions. Assign a student to write the predictions and outcomes on the chalkboard or on a poster. Have other students making their own chart of predictions and outcomes at their seats. Be sure to allow time for students to compare their predictions with one another. The following items are recommended to see if they float, sink, or stop in between layers: moth ball, lead sinker, rubber stopper, oak, cork, pine, and plastic. This activity leads right into the next one, what makes an item float or sink.

What floats?

Aluminum can

Aluminum is a common metal that we see and use all the time. Ask students if they think all metal sinks. Then ask about the particular example of aluminum, what would happen if we filled an empty aluminum soda can with water and placed it in a bucket of water? Have students try this. They might be surprised that aluminum is light than water and therefore floats.

Soda can versus diet soda can

Next see if students can predict what will happen to a can of diet soda and a can of regular soda when on puts them in water. To make these as comparable as possible, use both the same brand and type of drink except for the diet aspect. The sugar dissolved in the water in the non-diet drink makes that drink heavier so that it sinks. Also the carbon dioxide bubbles dissolved in the water would make both cans more likely to float.[1]

Students could also use a basic balance scale to compare the two cans of soda, one diet and one regular. They may also want to have controls of comparing two diet sodas on the balance scale or two regular sodas to see how consistent the weight of each can is.

Why Boats Float

This isn't exactly kitchen chemistry, but follows well from the previous experiment and uses household materials. Also it shows more about density. Students sometimes ask why a boat floats. Most of what the boat is made of is heavier than water and in most people's experience, would sink. This activity should help students understand that even though something may be more dense

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1from Adventures with atoms and molecules by Mebane and Rybolt, p. 19

than water, it can be shaped to take up more space and because of its shape, it will float. One needs to give students a piece of clay that they then divide into 2 pieces. the first piece they simply shape into a ball. The second piece they shape into a boat or a hollowed out rectangle (with a bottom and 4 sides). At this point it is important to have students compare the amount of space taken up by the ball of clay and the amount of space taken up by the boat. Putting both clay pieces in water, with the boat with the hollowed side up, should produce a sinking piece of clay and a floating piece of clay.

Students may then be asked to write a description of what they did to help reinforce the idea that they have learned about what enables boats to float. This may be a demonstration that they would like to take home and show their parents and siblings.

Base, Acid, and Neutral Investigations

Acids - Experiment 1

You can begin introducing the concept of an acid with talking about why lemons taste sour, that many of our common, everyday foods are acidic. Some acids are much too strong to ingest and would cause a great deal of harm. Some acids burn the skin.

To show students the strength of 2 acids in their kitchen, you can begin a slow experiment that will take some time. You may want to begin these well before you begin talking about acids.

First, you take a piece of aluminum foil, and cover it with tomato sauce. You can put a small piece of aluminum foil on the bottom of a see through container, where you can hold it up to look at the bottom and check on the aluminum foil. This probably needs to be stored in the refrigerator so it doesn't spoil while it eats the aluminum foil. This needs several weeks.

Acids - Experiment 2

A quicker experiment uses clear vinegar to remove the shell from a raw egg without breaking it. Place a whole raw egg in a class jar without racking the egg. Cover the egg with clear vinegar and close the lid on the jar. Observe the egg over the next 24 hours. The acid will begin reacting with the calcium carbonate (what the egg shell is made of) immediately and begin forming bubbles of carbon dioxide. After 24 hours, the shell will be completely off the egg, although some portions of it may be floating in the vinegar. The egg will still be altogether, protected by a thins see-through membrane from the outside. Students should be able to see the egg yolk through the membrane.

Acids - Experiment3

You may want to introduce this experiment by talking about chalk being made of a mineral called limestone. Limestone is sometimes used to make buildings and statues. Let the students know that you are going to find out what effect acid has on chalk.

Taking two pieces of chalk put them in 2 bowls one labeled water and one labeled vinegar. Cover the respective pieces of chalk with vinegar and water. Watch what happens. After several minutes you should see bubbles of gas coming up in the bowl that has vinegar. This is the acid in vinegar reacting with the chalk and forming carbon dioxide gas. Leave the chalk in the bowls over night. Take the pieces of chalk out the next day and compare their sizes. The one in the vinegar will have gotten smaller because the acid in the vinegar will have caused it to form calcium ions and carbon dioxide. Acid rain can hurt some buildings and statues in the same way. You might want to mention that acid rain also effects living things.

You may want to talk about how acids taste sour. We use them in a variety of foods that we drink or eat with sugar added to contrast the sour taste. Sometimes sugar is added to tomato sauce, probably because of its acidity. Remind students that lemonade is acidic as is soda and that we might not like them as well if they did not have sugar added. You could make your own lemonade, letting students taste a small portion of it before you add the sugar.

Bases

One way to find out if something is a base is by getting it wet and feeling it. If it is a base, it will feel slippery.

Measure 1 tablespoon of baking soda, laundry detergent, cornstarch, sugar and salt into different containers. Feel each one to see if they feel any different from each other. Then add about 1 cup of water to each container and stir feel how each solution feels, being sure to wash hands in between solutions.

Cabbage water base/acid/neutral test

Students can check the acidity/ baseness of a variety of solutions made from kitchen items.

To test different solutions for acidity, first have the students prepare some cabbage water. You may want to prepare this a day ahead of the rest of the experiment. You don't even need to heat this up. Tear or cut up red cabbage into small pieces and soak in water until the water turns red or you can cook the cabbage for about 20 minutes.

Each set of students needs to have 8 small cups (1 or 2 ounce cups)and a larger cup of the prepared cabbage indicator water. Each set of students should also have a chart, where they label what is in each of their cups. Students should have additional space to write down any combinations they make after they have done the initial eight trials. They need to have a predictions column as well as an outcome column.

Have students carefully label their cups so that they will be able to keep track of what solution is in each small cup. Then they need to put small amounts of the following solutions in their small cups: 1 pint of water, 1 pint of water with 1/2 cup of baking soda, 1 pint of water with 1/4 cup mild of magnesia, 1 pint of water with 1/4 cup salt, 1 pint of water with 1/2 cup sugar, 1 pint of vinegar, 1 cup lemon juice, and 1 pint tonic water. Each group of students needs to pour some of the cabbage indicator water into their small cups of solutions and watch the color change.

If the indicator turns the solution red or pink, the solution is an acid; if the indicator turns the solution purple, the solution is neutral; and if the indicator turns the solution blue or green, the solution is a base.

The students might enjoy predicting what would happen if some of their solutions are combined. They can predict and then try it and find out what happens. They can do this with several different combinations, predicting, and trying each one at a time. Do they get better at predicting what will happen?

Chemical Reactions

Mixtures and solutions are not formed by chemical reactions. They are just mixed together physically and can be separated by physical means. They also still retain their same chemical properties. A chemical change may give off heat, result in a product of a different color, or give off an odor. So let's look at some examples of chemical changes.

If you take a 1 liter plastic soda bottle and pour baking soda into the bottle. Put pour vinegar into a balloon, attach the balloon so that it covers the mouth of the bottle, and let the vinegar fall down into the baking soda. The mixture begins to bubble and the gas given off (carbon dioxide) inflates the balloon.

Another reaction that shows a noticeable difference is producing a green blob from iron acetate and vinegar. First put a steel wool pad into a jar and cover it with vinegar. This will produce iron acetate in about 5 days if left undisturbed. Pour 1 tablespoon of the liquid iron acetate into the second jar. Add 1 tablespoon of household ammonia and stir. This will produce a dark green, jelly-like substance.. In this, ammonium hydroxide and iron acetate combined to form ammonium acetate and iron hydroxide. No new types of elements were produced (since elements can not be made with chemical reactions) There was simply an exchange of materials to make different combinations. You can see this in the names where ammonium's if first with hydroxide and later with acetate, with iron is first with acetate and then turns into iron hydroxide.

Analytical chemistry

This is a chance to show the students a bit of what an analytic chemist actually does. An analytic chemist finds out what is in substances. Here the students make up four clear solutions, let someone pour them into various glasses in any combination, and then with indicators the students can tell what was put into the glasses.

The four solutions are 1.)plain water, 2.) a quarter teaspoon instant laundry starch dissolved in a quart of warm water, 3.) four teaspoons of sodium bicarbonate dissolved in a quart of water, and 4.) four teaspoons bottled lemon juice dissolved in a quart of water.

The indicator solutions are a.)base indicator, made by taking the juice from a can of cooked red cabbage or putting chopped red cabbage in a pot with water, boiling it for 20 minutes and using the red liquid that one gets for that, b.)starch indicator, tincture of iodine from a medicine cabinet or drug store, and c.) vitamin C indicator, 1 cup of the starch solution (#2) mixed with about 10 drops of tincture of iodine to make it a dark blue.

Indicator a.) base indicator will turn blue if there is sodium bicarbonate in the solution (solution #3).

Indicator b.) starch indicator will turn the solution blue.

Indicator c.) vitamin C indicator is blue and will remain blue if there is no lemon juice. If it turns the solution clear, then lemon juice was there.

Now, you have someone mix the solutions into empty glasses. The person mixing the solutions needs to pour 1/4 cup of any chosen solution into whatever glasses she wants. So she can put 1/4 cup of solution 1, 1/4 cup of solution 2, 1/4 cup of solution 3, and 1/4 cup of solution 4 all in one glass, and any combination of solutions in each of 3 glasses, as long as she puts 1/4 cup in at a time. Now, she will need to make a list or chart of what she has put in each glass. A chart would probably be best. Have the students make a chart having the solution numbers across the top and glass numbers along the side, then the person mixing can just check off each solution he puts in each glass.

Next, a group of students should check to see what was put in the mystery glasses. To do this, a group of 4 students could act as a team, one person could be in charge of keeping a written record, one each could be in charge of testing using one of the indicator solutions. The students need to keep careful records, perhaps with the name of the indicator solution and the color that it turns if the presence of that solution is there.

First the recorder should put two teaspoons of the glass they are testing in each of three little test glasses. Then he records as the person with the with the base indicator add one teaspoon to his glass and sees what happens; if the test glass turns blue, then a base - sodium bicarbonate is in the liquid. Next, the person with the starch indicator would put a few drops of tincture of iodine in his sample; if this test glass turns blue, then starch is present. The third person needs to add one teaspoon of his Vitamin C indicator solution; his solution will turn clear if there is vitamin C present (in the form of lemon juice).

This is quite complicated and a good chart will be absolutely necessary. If students have been charting other experiments well it might be good to see what the students do in charting without a lot of direction. This could be a fun demonstration to ask other classes to observe or the secretary, or another teacher after the students have done it several times and gained familiarity and adeptness at it. If you have not strictly supervised their charts or made the charts for them, you might lead them in a discussion of what information they needed on their charts. Perhaps the class as a whole could design a better chart for when they do demonstrations in front of others.

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Student Reading List

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Materials

oil baking soda

detergent laundry detergent

2 jars cornstarch

sugar
for each group: salt
4 clear bottles
4 marbles red cabbage
honey milk of magnesia
roll-on anti persperant lemon juice
hair gel tonic water
stop watch or clock with a second hand balloon
plastic soda bottle
dark Karo syrup or maple syrup steel wool pad
glycerin household ammonia
Dawn dishwashing liquid (in a color) instant laundry starch
vegetable oil sodium bicarbonate
rubbing alcohol tincture of iodine
moth ball small plastic glasses
lead sinker larger plastic glasses
small rubber stopper
small piece of pine
small piece of oak
small piece of plastic
empty aluminum can of soda
2 cans diet soda
2 cans regular soda
play dough
tomato sauce
small piece of aluminum foil
vinegar
raw egg
2 pieces of chalk
lemons
sugar

Content standards addressed by this unit:

1. All students explain how scientific principles of chemical, physical and biological phenomena have developed and relate them to real-world situations.
2. All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological and earth sciences.
6. All students develop and apply skills of observation, data collection, analysis, pattern recognition, prediction and scientific reasoning in designing and conducting experiments and solving technological problems.