

Recognizing Chemical Reactions

By Dr. Kathleen Vandiver

Hello. My name is Dr. Kathy Vandiver. And we're here at the Edgerton Center at MIT, a university in the United States. And the Edgerton Center is named for a famous professor whose name is Harold Edgerton. He did a lot of work in high-speed photography.

However, today our topic is chemical reactions. So when I say the word chemical reactions, what comes to mind? Is it something like this? I see gas forming here. Is this a chemical reaction? So how can you tell whether a chemical reaction has happened? I'd like to know your ideas. So why don't you turn and talk to your neighbor. And then your teacher will collect your ideas, and I'll be right back.

So welcome back. I'm thinking about what you might have written on your list. And I bet you it might have something to do with explosions or color changes. And these are really interesting observations. However, there are some things that all chemical reactions have in common.

The definition is that new substances have to be produced. So this is something we're going to apply to our lesson today. And we're going to think a little bit more broadly about chemical reactions.

For instance, you may not think of it yourself, but you are full of chemical reactions. Right now you're making new bone, new DNA. Those are all brand new molecules. And those are chemical reactions, too. But we don't often think of chemical reactions in living things.

Today we're going to get started in thinking about the obvious changes that we can notice as chemical reactions. And in class today we're going to do some exciting and obvious ones. In our class we always have a list of safety regulations. And I hope that your teacher will explain those to you, too.

Here's the procedure. The class should do each step together. Step one, put one teaspoon of baking soda into the resealable bag. Step two, put two teaspoons of calcium chloride into the same bag. Step three, place the test tube with 10 milliliters of phenol red solution into the bag, and hold it upright.

Step four, remove the top of the test tube. While holding the test tube upright, squeeze out all the air of the bag, and seal the bag. Have your partner make sure that the bag is well sealed. Step five, tip the tube of all phenol red solution into the solids. Mix gently with the outside of the bag with your fingertips. You can let the test tube fall to the bottom and watch.

Now it's your turn to try out this chemical reaction. Work with your classmates. And I'll be back in a few minutes.

All right. Welcome back. I hope that was lots of fun and also that you discovered some things that you expected, actually did happen. For instance, there was some foaming and some color change. (But I hope you had no explosions!)

But anyway, remember that the real definition of a chemical reaction is that new products are formed. New substances, new molecules are going to appear. So that's what we're going to concentrate on next. We're going to take a look and see if we can discover the new molecules that were formed here.

All right. So let's see now if we can make a discovery about what new products or new molecules were formed in our chemical reaction. The bag here changed. We saw a gas forming. And right now we can figure out what the gas is.

With a flame test, we can put in match. And we can see if there's a popping sound-- then we'll know it's hydrogen. If the flame starts to glow more brightly, we'll know it's oxygen. And if it goes out, then we'll know it's carbon dioxide. So let's try it.

So here's our flame test. It's carbon dioxide. And they're going to be other things that are new molecules in the bag, as well.

One of them is table salt. So we've got table salt produced here. We also have produced some chalk. It's that white stuff at the very bottom now-- kind of gritty, if you feel it. And also the one thing we can't really see too clearly is ---we produced a few new water molecules.

So in the next part of this program we're going to go with you and take a good look at how we can separate out these new molecules from the mixture and prove that we have these new substances being formed. What your teacher will be doing is collecting the materials that were produced in the bag. And I've added a little bit of water to make it easier to pour. And we don't have to worry about the water. We're going to evaporate it off later.

So what we're doing is we're collecting the molecules that we made so that we can investigate them and find out exactly what they are. Here's a second bag. And I've chosen to pour it into a graduated cylinder, this long column, because the chalk that we've made, the new molecule of chalk, they're all going to sink to the bottom and form a precipitant down here. And the sodium chloride, the table salt, and water, the new molecule of water that we have, will be up in the top here. And we'll be able to separate them.

OK. So after we have our graduated cylinder full of the products that we've made in the bag, what we can do is we can re-suspend it a little bit. And we can pour it through this filter. This filter is going to catch the chalk molecules and let through the sodium chloride, or the table salt, and water to the bottom. And after it's filtered a little bit more, I'm going to be able to pour off the liquid down here into this dish and let the water evaporate. And we'll wrap up the chalk that's in this paper to make chalk that you could write on the board with.

So next, your teacher is going to spend the time to write out the equation for us, so we can see the entire chemical reaction. And in this process, we're going to get a chance to see what happens to each atom in the chemical reaction. So take the time to do this. And I'll see you after the break.

Welcome back. By now you've seen that the atoms in a chemical reaction get rearranged. Our next step is really to get a chance to model that using these LEGO bricks. Right here we have a sample of carbon. So carbon is black. And the smallest piece of carbon, the element carbon, would be an atom. So this would be an atom of carbon.

We have other colors, as well. So red represents oxygen. And each one of these bricks is an atom of oxygen. So the air we're breathing contains O₂. So this is a molecule of oxygen.

And for other colors which we'll also use, for example, this is an atom of hydrogen. And so when we build a molecule of water, we would end up creating this, which is H₂O, as you know. So here are the hydrogens. Here's the oxygen. And were we to represent carbon dioxide, you can see that we'd use the black for the carbon and the two oxygens here to build a molecule of carbon dioxide.

Now we're ready to model the reaction.

Hi. I'm Jessica Garrett, and I work at MIT. I'll be showing you two ways to model the chemical reaction we just learned about. Let's follow the atoms in our chemical reactions through an animation.

Each circle represents one atom from a different element. The black circle with this C represents one carbon atom. The red O is oxygen. The light green Cl is chlorine.

The pink Na is sodium. And the dark green circle with the Ca is a calcium atom. The small white circle with an H represents one hydrogen atom. It is the smallest atom.

Here the atoms are bonded together into molecules. We started with these molecules in our chemical reaction. Notice which atoms are in each molecule.

Here is one molecule of calcium chloride and two molecules of sodium bicarbonate, which is commonly called baking soda. Are you ready? Let's watch the reaction.

Here we show all atoms separating from each other. They will form new bonds to make new products. In nature, the atoms go through several steps before reconnecting to make new products.

Here are the products at the end of the chemical reaction. We have the exact same atoms. But they are rearranged into new groups. They are now new molecules.

The new molecules are ones that you know-- chalk, salt, carbon dioxide, and water. Chemistry is really amazing.

Let's take a look at using LEGO bricks. We can visualize what happens to the atoms in this chemical reaction by modeling with LEGO bricks. If you have these materials, this is what you will be doing. Remember, each color brick represents a different atom.

When clicked together, the bricks form a molecule. Here are two baking soda molecules and one calcium chloride molecule. These are the reactants.

In the chemical reaction, these atoms will separate and recombine into new molecules. The sodium and chlorine form two sodium chloride molecules, or table salt. Two oxygen atoms and one carbon bond together to form the gas carbon dioxide. Remember all the fizzing?

Two hydrogen atoms and an oxygen atom bond together to form water. Finally, three oxygen atoms, one carbon, and one calcium bond together to form a molecule of chalk. In making these new products no new atoms were needed and none were left over. Amazing. We just demonstrated conservation of mass.

So start by building the molecules you know that went into the bag originally, which was baking soda and calcium chloride. There was some phenol red there. And that water just helped the molecules get close enough together to react. So essentially you'll rearrange those molecules to produce our new products.

Welcome back. We really hope that the bricks helped you visualize what was happening with the atoms. And now it might be useful to take a look at that original footage that we showed you about the test tube and see what was happening with the atoms in that one.

In that case, we were actually heating water molecules. And so when the water molecules were a liquid, they were moving rather slowly and not too far apart. However, with the heat what happened was the molecules gained energy. And after a while they gained so much energy they could become water vapor. And they were moving faster and more furiously. So at that point the cork popped off.

So today we've had a chance to experience a chemical reaction in the plastic bag. And we've also had a chance to look very closely and re-enact what really happened there. The fact that atoms can join with each other and create new molecules and new products, which can happen very exciting results. So I hope today as you walk around and you look at changes that you'll be able to recognize when a chemical reaction occurs.

To wrap it up, when you see a change occurring and you wonder if it's a chemical reaction, now you know to look for new molecules to appear. Thanks for watching.

(Teacher Guide)

Hi. My name is Kathy Vandiver. And I'm pleased to be able to talk with you a little bit more about this lesson.

The lesson is actually designed to make sure to help your students tell the difference between a physical change and a chemical change. And so in the beginning of the lesson, we'll start off by showing something that looks pretty confusing. Actually what it will be is a physical change. We'll be boiling water but perhaps suggest that it might be a chemical change.

And therefore, what we're going to do next is collect-- what you'll be doing during the break is you'll be collecting a list of what students would think of when you say the word chemical change-- or chemical reaction. And so the words that they may come up with are color change, explosions, things like that. And we need to collect those in the beginning to get an idea of their preconceptions.

The point is that these may indicate chemical reactions or maybe not. And so what we're going to focus on in the lesson is drawing through the idea that you need to have new substances being formed. So in your first break, you'll just collect from their students their ideas and preconceptions.

So after that, and after the break, we'll come back, and we'll start in to explain to the students what they will be doing-- some chemical reaction which will be very interesting. And I will explain a little bit about the chemical reaction. But I wanted you to be prepared to lead them step by step.

We have worksheets which are good for the students to use. And they delineate each step. And so your students can stay together.

It's very important they stay together at step one at a time, step two at the time and that you wait and pause and make sure that everyone is ready for the next step. Because the fun is really in the last step where everyone will tip the phenol red at the same time, and the chemical reaction will start at the same time. So every will have the fun of seeing the changes happen. So it's your job in the second break particularly to go through the steps and keep the students together during that time.

The bags are going to swell as the carbon dioxide is made in the bag. And you need to forewarn students if the bag gets a little bit to full that they should open it and release some of the gas. So that's just a little word to the wise and an awareness for the first time you do it in class.

Next what I'm going to explain in the video is how to demonstrate the new substances or new molecules were formed. And the carbon dioxide is rather obvious because we can see the gas actually blowing up the bag. I will do a splint or a flame test which helps identify the gas as carbon dioxide. And I'm going to go through and show the products that are created.

In case you don't have time to do them that day-- it does take quite a bit of time for the water to evaporate and to go through these steps. And it's nice for the students to see this real time. But you're welcome, and I encourage you, to follow the steps that I show in the video in class, so your students can actually see the products and try them out themselves.

So our steps will include, first of all, identifying carbon dioxide. And then later on we will identify the chalk because the chalk will settle out. And we also will identify the sodium chloride.

We cannot really show that one or two new water molecules are made. But students don't seem to have much problem with that. We really do explain that the water is added in the beginning into the bag because we need to be able to bring the molecules closer together in order to have the chemical reaction.

So, overall, we're going to end up showing the products which are really amazing because we started off with something that was edible like baking soda and calcium chloride, which is actually a poison and we end up with something really different, which is chalk that you could write with and this beautiful crystals you can get from sodium chloride.

So that concludes the video explanation about what happens next. And what you will be doing in the break, what I'm really hoping you'll be able to clarify well, is I would like for you to write out the equation so that the students can actually see all the molecules. And in that case, we also have this sheet of paper, as well, in the student handout. And now we can identify the molecules by their chemical formulas.

And at this point, this break time that you have is really, essentially, to make sure that we're showing the conservation of mass. So we can start out by looking over here and seeing how many oxygens there are and crossing them out. So over on this side we have six oxygen molecules, and you can find all six on this side, as well, and cross them off. So just to do the housekeeping and showing that all the atoms still appear and have just changed partners and rearranged. So that time period is your break period where you can explain what is happening really atom by atom.

So that leads us very nicely into thinking about atoms and actually what each atom is doing. And that leads us also into being able to have the students participate in teams of two with these bricks which can really clarify what's going on in a chemical reaction. So the students will work in teams of two. And what we have also available, easily to download, these diagrams of the actual models that we can make from the bricks.

And the students start off by making one of each one of these and putting it on the picture. And then what we can do is we can put the rest the bricks away and then after that the students can rearrange this into being the chemical products, the new molecules. And, therefore, it's really easy as a teacher to have demonstrated the conservation of mass. And it's really exciting because the kids are always pleased when they discover there are no atoms left over. And all of them have been used and represent things that they have heard about or seen as crystals or as chalk on the board.

So after the brick modeling has been concluded and these materials had been put away, the last part of the video helps to visualize what happened in the test tube demonstration that we did originally. And here is the demonstration, really, of a physical change. The water molecules are just moving from being liquid to being a gas or water vapor. And so it's really quite clear that something that might have been confusing in the beginning-- whether or not it was a chemical reaction-- now your definitions can make it really clear that it was a physical change.

So I hope this ends up helping you in your unit and study with your students about chemical reactions and that it becomes a lot easier and much more enjoyable to teach.