The Nature of Chemical Change: Acting Out An Example

Developers:

Ms. Virginia Corcoran
Amosland Elementary School
Ridley, PA

Dr. Carl Hemenway
Rohm and Haas Company
Bristol, PA

Grade Level: 3 through 6

Discipline: General Science

Goals: To illustrate the molecular nature of matter and to show that chemical change involves alteration of molecules.

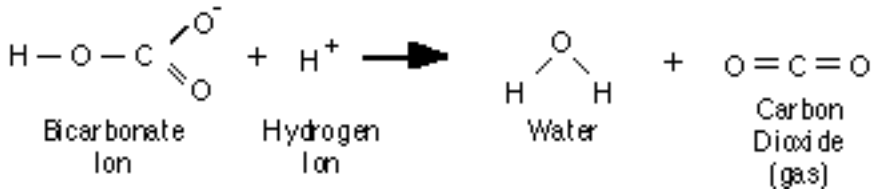
This activity provides a specific example of a chemical change. It is designed to follow previous work in which the students discuss, in general, the difference between physical change and chemical change. This activity will work to aid any teaching unit on chemical change, although it was originally designed as a supplement to Windows on Science, a videodisc-based curriculum program (Optical Data Corp., Warren NJ).

Vinegar reacts with baking soda to form bubbles of carbon dioxide gas in a simple, well-known chemical reaction. The teacher can demonstrate this reaction, and the students can "act out" the roles the molecules play in the reaction.

Vinegar is mostly water, with a few other chemicals dissolved in it to give it color, flavor, and acidity. The acidity comes from a small amount of acetic acid, which has the chemical formula CH_3COOH. Most of the CH_3COOH molecules stay intact, but a few of them separate into two parts: the hydrogen ion (H^+) and the acetate ion (CH_3COO^-). The acetate ion does not participate in the reaction with baking soda, so we ignore it in the "role playing." For this exercise, vinegar will be a lot of water (H_2O) molecules with a few hydrogen ions wandering around among them.

Baking soda is a white powder made of a pure chemical called sodium bicarbonate ($NaHCO_3$). When this powder is added to water, it separates completely. Every molecule separates into a sodium ion (Na^+) and a bicarbonate ion (HCO_3^-). The sodium ion does not participate in the reaction with vinegar, so we will ignore it in our molecular drama.

The chemical reaction is written like this:



Materials: Quart of white vinegar; small box of baking soda; 500 mL glass beaker (or sturdy canning jar); tablespoon; paper (one sheet, 8-1/2 X 11 inches, for each student); broad marker; tape.

Management: This exercise consists of a brief demonstration followed by some participatory activity. It should be complete within a one-hour period. The participatory activity requires a large space, so it should be performed in a gymnasium or outdoors.

Procedure:

1. Demonstration:
   The teacher should wear safety glasses while performing the demonstration. The individual materials are nonhazardous, and the chemical reaction is mild; but you should always wear glasses when conducting chemical experiments.
   Pour vinegar into the beaker, so that the beaker is about half full. Add one tablespoon of baking soda to the vinegar. Ask the students to observe what happens. Discuss how the fizzing and bubbling are different from physical changes.

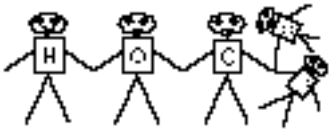
2. Molecular "Role Playing"
   Move to the gym or playground. Make a "beaker" on the ground by drawing three sides of a square, with each side about 15 feet long.
   Each student will be an atom, either Hydrogen (H), Oxygen (O), or Carbon (C).
   Here is a sample of how to group a class of 25 students into molecules:
   Take 3 students; use the 8-1/2 X 11-inch paper to label 2 of them as "H" and one as "O". Instruct the O student to hold hands with the two H students, like this:

This group is a water molecule. Tell the water molecule to keep their hands clasped, and to wander around randomly inside the "beaker." They will continue to hold hands with each other, but they will not clasp anybody from any other molecules. Make 5 more water molecules and set them all to wandering around together in the beaker. Each molecule should walk around aimlessly, and they should (GENTLY) bump into each other and into the sides of the "beaker."

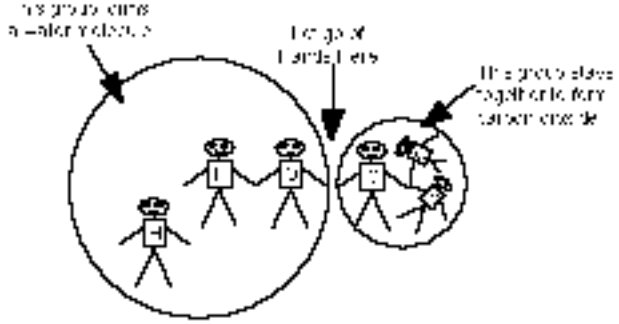
Pick a lone student and give a label "H." Tell that student to go into the beaker alone and wander around. Pick another lone H to wander around, too.

You now have "vinegar" in the beaker: mostly water, with a few hydrogen ions around to make it an "acid."

The remaining students should be labeled with one "H," one "C," and three "O." They should hold hands something like this, to form the "bicarbonate" ion:



The bicarbonate group should approach the open "top" of the beaker and start to enter the group of water molecules. As a group, they should wander around until they get near a lone H ion. At that time, they "react" with the H ion, like this:



The new water molecule joins the other water molecules in wandering around the beaker. The new carbon dioxide molecule wanders toward the open end of the beaker and leaves the beaker.

Closure:

In discussing the demonstration and role-playing with the students, the teacher should be sure that the following key points are covered:

1. Matter is a collection of tiny molecules.
2. Each molecule is a collection of atoms.
3. In chemical changes, the molecules break apart, and the atoms form new combinations.
4. The clues that a chemical change has taken place: color change; temperature change; phase change (new solids, liquids, or gases).
   After the class discussion, the students should retell the "story" of the chemical reaction in their own ways. Something other than humans should be the atoms (animals, clouds, blobs of jelly, houses, cars, or whatever), and the story should involve the key points of separation and regrouping. Older students could write the story as a prose narrative; younger ones could draw cartoons or even just "before" and "after" pictures.

Ridley School District - Grade 3

Matter and Energy Unit - Overview

Concept 1:

Matter is anything that takes up space and has mass. Matter can be defined by its properties.
Learning Outcome: Children will classify matter by properties.

Activities:

1. Sort boxes
2. Language Arts tie-in (adjectives)
3. Ice cube in Alcohol/Water for unseen properties
4. Oobleck

Concept 2:

Matter exists in the form of solid, liquid and gas.
Learning Outcome: Children will experience matter in its three states.

Activities:

1. Test if air has weight using balloons
2. Acrostic or collage of solid, liquid and gas
3. Evaporating ice

Concept 3:

Matter is made from particles too small to be seen, called atoms. The movement of atoms relates to the state of matter.
Learning Outcome: Children will physically and visually depict the atomic structure of matter in its three states.

Activities:

1. Use bodies to show arrangement of atoms in solids, liquids and gases.
2. Use marshmallows.
3. Have SLG Treats (Ice cream sodas).

Concept 4:

Temperature is a property of matter.
Learning Outcome: Children will measure temperature of matter.

Activities:

1. Practice with thermometers inside and outside.

Concept 5:

Heat energy causes the movement of atoms. A conductor is matter that allows heat to move easily, an insulator is matter that slows the movement of heat.
Learning Outcome: Children will create effective conductors and insulators.

Activities:

1. Magic trick using pennies
2. Testing materials in heat
3. Great ice cube contest (making insulators)
4. Is your hat a good insulator

Concept 6:

Changes in matter when heated or cooled.
Learning Outcome: Children will demonstrate the following changes in matter: condensation, evaporation, melting, freezing, contraction and expansion.

Activities:

1. Task cards for cooperative groups to work at stations.
2. The great meltdown
3. Paint with melted crayons.

Concept 7:

Physical change is a change in matter without changing the atoms. Chemical change is a change in matter in which a completely new type of matter is formed.
Learning Outcome: Children will create chemical change and will be able to differentiate chemical change from physical change.

Activities:

1. Stations set up for cooperative groups.
2. Vinegar and baking soda reaction using bodies as atomic model.

Concept 8:

People physically and chemically change matter to make it more useful.
Learning Outcome: Children will be able to change matter physically and chemically to make a new type of matter.

Activities:

1. Lemon fizz
2. Experimenting with the amount of baking powder in pancakes and cupcakes.
3. Invent-a-new-use. Recycling or physically changing used matter to make something new.

Chemistry in Cooking

Some chemical changes form gases as a product, as in the case of baking soda and vinegar. When the reaction takes place in a liquid, the bubbles rise to the surface and can be easily observed. When the reaction takes place in a batter that is being warmed, the bubbles get trapped and are permanently set. This reaction makes baked goods airy and soft instead of hard and flat.

Try these two recipes with your class to experiment with the effects of baking powder in foods.

Divide the class up into three groups with each group adding a different amount of baking powder to the recipe.

Basic Cupcake Recipe

This recipe makes 4 cupcakes. Group 1 will add 1/2 tsp of baking powder to the dry ingredients, Group 2 will add 1 tsp., and Group 3 will add 1-1/2 tsp. of baking powder.

1 cup flour
1/2 cup sugar
1 egg
1/4 cup butter (room temp)
1/4 cup milk
1 tsp vanilla
? baking powder

Mix dry ingredients. Each group adds the required amount of baking powder. In another bowl mix butter, eggs, milk and vanilla. Add wet ingredients to dry and mix until flour is moist. Beat till smooth.

Bake in a 350 degree oven for 15 minutes. Compare and enjoy. You will notice differences among the cupcakes in crumb size, height, and taste.

Pancakes
For a breakfast treat for your class, make pancakes. This recipe yields 12 pancakes. Vary the amount of baking powder with each batch.

1-1/2 cups flour
1 tsp salt
3 tbsp sugar
1 lightly beaten egg
3 tbsp melted butter
1-1/4 cup milk
1 tsp baking powder (Batch 1)
1-3/4 tsp. baking powder (Batch 2)
2-1/4 tsp. baking powder (Batch 3)

Use a few quick strokes to moisten dry ingredients. Don't overbeat.