VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Chemistry in a Ziploc Bag (7th Grade)

Mini Lesson for Fall 2018

GOAL: To use the scientific method to explain observations made when calcium chloride, sodium bicarbonate, water, and phenol red are mixed.

Fits TN State standards: 7.PS1.2, : 7.PS1.3, : 7.PS1.4: 7.PS1.5

LESSON OUTLINE

I. Introduction

Explanation of the scientific method and the importance of observations.

II. Experiments

A. Experiment: Students observe the changes that occur when four different substances are mixed.

B. Using the Scientific Method. Students brainstorm how to determine the roles of the different reagents.

C. Applying the Scientific Method. Students observe what happens when just two reagents react, then 3 reagents and then all four.

III. Observations and Explanation

IV. VSVS Background Information on Chemical Equations

1. In the car ride before the lesson, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Lesson Quiz

1. Why are scientific observations important? Why do they need to be recorded?
2. What happens when calcium chloride is added to the baking soda and then phenol red solution?
3. What are some of the possible student observations? How can they be explained?
4. What must scientists do when changing variables in an experiment?
5. What evidence of chemical reactions was observed?

2. Here are some Fun Facts for during the lesson:

1. **Phenol red**
   - It is used to test the pH of swimming pools. It is sometimes called "guardex solution #2"
   - It is used to monitor the pH of cells in cell culture. An excess of waste or bacterial contamination will cause the media to become acidic and the phenol red will turn yellow.
2. **Calcium chloride**
   - It is put on roads in winter because it lowers the freezing point of water, preventing ice from forming.
   - The extremely salty taste of calcium chloride is used to flavor pickles.
3. **Baking soda**, or sodium bicarbonate
   - Why is baking soda used in baking? Baking soda reacts with acids in cake or cookie mixes to create carbon dioxide (similar to this experiment!) which creates bubbles that make the batter to expand ("rise").
   - It can neutralize acids and is used to treat indigestion, heartburn, and burns.
   - It is an ingredient in some toothpastes, mouthwashes, deodorants and shampoos.
   - Some types of fire extinguishers use baking soda to put out fires

MATERIALS

Note: Be sure you have all of the materials before you leave the lab.

13	plates
13	1 oz cups marked at the 15 mL level
15	Ziploc sandwich bags containing one teaspoonful of baking soda
1	250 mL container of phenol red solution
13	dropper bottles phenol red
10	extra Ziploc sandwich bags
13	jars $CaCl_2$
13	jars $NaHCO_3$
13	stirrers
13	bottles water (100ml)
13	thermometers
26	taster spoons
25	paper towels
13	sets of 1 test tube rack and 3 test tubes
1	trash bag
	pencils (students use their own and need to have them ready to record observations)
1	PowerPoint/binder containing ppt, 36 Observation Sheets

I. Introduction

Organize students in threes

Give each student an Observation Sheet.

While one VSVS member gives the following explanation, other VSVS members should pour phenol red solution in the 13 1 oz cups marked at the 15 mL level.

Explain to the students that all scientific knowledge is a result of careful investigation and observations. New discoveries and advances in science depend on having a careful and accurate record of observations made while investigating a question. That is why it is important to make accurate and detailed observations. Following observations, scientists make a hypothesis, or try to explain their observations. They then design an experiment that tests their hypothesis.

NOTE: Phenol red solution is an acid-base indicator which turns purple in a basic solution and yellow in an acidic solution.

II. Making Observations When Calcium Chloride Is Added To Baking Soda/Phenol Red Solution

Learning Goals: Students record observations during chemical reactions

IIA. Experiment – Students do the Experiment in a Ziploc Bag

Write the following chemicals on the board:

sodium bicarbonate $NaHCO_3$, calcium chloride $CaCl_2$, water H_2O, phenol red

Ask students*: How can you tell when a chemical change has occurred?*

Tell students what evidence to look for to determine if a chemical reaction occurs: **a color change**, **a gas given off**, **temperature change, formation of a precipitate or a new chemical substance is formed.**

Give each pair one Ziploc bag containing baking soda, one 2 oz cup containing 15 mL of phenol red solution, and one plate.

Tell students write down their observations.

Your Notes:

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Instruct the students that one person will be holding the bag while the other will write down all observations possible.

Tell students to:

1. Hold the bag upright over the plate.
2. Open the bag and add a teaspoon of calcium chloride.
3. Add the phenol red solution (includes water) to the bag and seal the bag.
4. **Gently** shake the contents of the bag while holding the bag over the plate.
5. Ask students what they observe. Record students observations about color changes, temperature changes (is the bag cold or warm or both since there can be localized heating), changes in bag size, and gas given off or foaming.
6. The reaction takes about three to five minutes.

NOTE: There is no danger of the bag exploding if the correct amounts of chemicals are used. Since everything is pre-measured, you should have no problems. In the event one does explode or leak, use paper towels to clean up any mess. If you have followed your directions, any spilled liquid will be on the plate, which can be easily wiped up with paper towels. Assure the students that the chemicals are safe.

Write student observations on the board.

Possible Student Observations:

(1) When calcium chloride was added to the baking soda, nothing happened.
(2) When the phenol red indicator in water was added to the baking soda/calcium chloride bag, the color started changing from red to yellow (some students may say they saw some pink color – accept this as well.)
(3) The bag became cold (for a short time).
(4) The bag may be warm in some spots.
(5) The bag fills up with gas. There are bubbles.
(6) The bag may become cold again after a while.

Ask students: What evidence for chemical changes did they observe in today's experiment?

1. A color change
2. A gas given off (this is a new substance)
3. Temperature changes
4. A white precipitate that is not obvious until the final mixture is allowed to settle out for some time.

Your Notes:

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II. Experiment B – Brainstorming To Determine the Roles of the Different Reagents in the Reaction .

Learning Goals: Students use the scientific method to design an experiment.

Write the overall equation on the board:

$2NaHCO_3$ (aq) + $CaCl_2$(aq) -----> $CaCO_3$ (s) + 2NaCl (s) + H_2O(l) + CO_2 (g)

For this section, students will brainstorm how to determine the role of each of the chemicals

Tell students that this cannot be easily determined by observing the reaction with all 4 chemicals, but it can be determined by systematically testing different combinations of reagents.

Tell students that they will determine which combination of chemicals produced the following observations:

1. The bag feels cold(er).
2. The bag feels warm(er).
3. The mixture fizzes, and the bag fills up with gas.
4. The mixture turns from red to yellow.

Take the students through the steps of a systematically designed procedure to test each observation by taking one reagent (called the CONSTANT) and adding another reagent (called a VARIABLE), one at a time. Once they are done with that variable, they will go on to the next one until all possible combinations are tested. Tell students that scientists design experiments that change only one variable at a time.

Make a list on the board (see below).

Tell students that the first set of combinations of chemicals will involve **sodium bicarbonate**.

Ask: What other chemicals should be added to sodium bicarbonate (one at a time) to investigate the observations made? (Refer to the chemicals written on the board – see above).

Note: When coming up with the list, you will come up with combinations that are the same as previous ones formed. In that case, **CROSS IT OUT ON THE BOARD,** and let students know that they do not have to test it because it would mean repeating an experiment. (Those that are repeated have strikethrough below).

A. If sodium bicarbonate is the CONSTANT what different chemicals can be added to change the experiment?"

1. $NaHCO_3$ plus water
2. $NaHCO_3$ plus water plus phenol red solution
3. $NaHCO_3$ solid plus $CaCl_2$ solid

B. Continue building the list with $CaCl_2$ as the constant:

4. $CaCl_2$ plus water
5. $CaCl_2$ plus water plus phenol red solution
6. ~~$CaCl_2$ plus $NaHCO_3$ BUT this is already listed in #3.~~

C. Continue building the list with water (H_2O) as the constant:

7. ~~H_2O plus $NaHCO_3$ BUT this is already listed in #1.~~
8. ~~H_2O plus $CaCl_2$ BUT this is already listed in # 4.~~
9. H_2O plus phenol red

Tell them that they will also need to do an experiment with a combination of three reagents. Write it on the board.

10. $NaHCO_3$ plus $CaCl_2$ and water (no phenol red indicator added)

Your Notes:

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IIC. Experiment: Students Make Observations When Controlling the Number of Reagents.

Pass out the following materials to each group of 3:

1tube rack and 3 test tubes
1 jar $NaHCO_3$ solid
1 jar $CaCl_2$ solid
1 bottle water (100ml)
2 spoons
1 stirrer
1 thermometer
1 tissue

Experiments		
	Reactants (calcium chloride, sodium bicarbonate, phenol red, and water)	**Observations**
Demonstration by VSVS team	H_2O plus phenol red solution	No changes
Experiment 1in test tube 1	$NaHCO_3$ plus H_2O	
Experiment 2 1in test tube 1	Add a squirt of phenol red to previous test tube	
Experiment 3 1in test tube 2	$CaCl_2$ plus H_2O **Warning – students must use 1small spoon only**	
Experiment 4 1in test tube 2	Add a squirt of phenol red to previous test tube	
Experiment 5 1in test tube 3	$NaHCO_3$ plus $CaCl_2$	
Experiment 6 1in test tube 3	$CaCl_2$ plus $NaHCO_3$ plus H_2O	
Experiment 7 1in test tube 3	Add a squirt of phenol red to previous test tube	
Experiment 8 in a plastic bag	$CaCl_2$ plus $NaHCO_3$ plus H_2O plus phenol red solution in plastic bag	

1. Tell students to follow instructions and to write their observations for each experiment.
2. At the end of **each** experiment, ask students what they observed. Write the results on the board.
3. Tell the class the reasons for the observations (see chart below) and write reasons on the board for students to copy.
4. Repeat for Experiment 2 in the same test tube.
5. Repeat for Experiment 3 and 4 in the second test tube
6. Repeat for Experiment 5, 6 and 7 in the third test tube

Ask students: What chemicals are responsible for the following

1. **The bag feels cold(er)?** The sodium bicarbonate mixed with water caused the temperature to decrease – see Experiment 1.

Your Notes:

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2. **The bag feels warm(er)?** The calcium chloride mixed with water caused the temperature to increase – see Experiment 3.
3. **The mixture fizzes, and the bag fills up with gas?** Experiment 6 showed that water, calcium chloride, and sodium bicarbonate are all necessary for this reaction, This is the only experiment that produced a gas plus temperature change. Since no other combinations produced the reaction observed in the Ziploc bag, we can conclude that all three reagents must be present.
4. **The mixture turns from red to yellow?** Phenol red is an indicator which turns red in basic solution and yellow in acidic solution.
   Nothing started bubbling or changing temperature when the phenol red was added in experiments 2 and 4.. Phenol red is not necessary for the reaction to take place., but it showed that a chemical reaction had taken place in Experiment 6.

Explanations for Results of Experiments			
	Reactants	**Observations**	**Explanation**
Demonstration by VSVS team	H_2O plus phenol red solution	No reaction	None
Experiment 1 in test tube 1	$NaHCO_3$ plus H_2O	Solid is slightly soluble; final solution color is cloudy white; the temperature of the solution is colder.	The temperature of the solution in the test tube decreases because baking soda absorbs heat when it dissolves in water. This reaction is **Endothermic.**
Experiment 2 in test tube 1	Add a squirt of phenol red to previous test tube	Solution color is cloudy pink/red	Baking soda ($NaHCO_3$) is weakly basic (pH of 8.4), so the color of phenol red indicator t does not change
Experiment 3 in test tube 2	$CaCl_2$ plus H_2O	$\mathbf{CaCl_2 \rightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)}$ Solid dissolves into solution and forms a cloudy mixture, then clear; the temperature of the solution becomes warmer.	Anhydrous calcium chloride gives off heat when it dissolves in water. **It is Exothermic.**
Experiment 4 in test tube 2	Add a squirt of phenol red to previous test tube	Color is red.	Phenol red does not change color.
Experiment 5 in test tube 3	Solid $NaHCO_3$ plus solid $CaCl_2$	No reaction	None
Experiment 6 in test tube 3	$CaCl_2$ plus $NaHCO_3$ plus H_2O	Bubbles form; fizzing sound is heard; test tube is cold to touch; solution color is cloudy white.	The test tube fills with carbon dioxide gas because the hydrogen ion (formed by ionization of bicarbonate) reacts with remaining bicarbonate ion to give carbon dioxide gas. There will be cold and hot spots, and the test tube continues to feel cold because heat is being absorbed. See equation below.

Your Notes:

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Experiment 7 in test tube 3	Add a squirt of phenol red to previous test tube	Color changes to yellow	CO_2 gas bubbles in water make an acidic solution.

Clean-up: The VSVS team should collect all Ziploc bags and used cups and put them in the trash bag. Make sure the Ziploc bags containing the reaction mixture are sealed before you put them in the trash bag. Then put everything else in the kit box along with the trash bag and return it to the VSVS lab.

IV. VSVS BACKGROUND INFORMATION ON CHEMICAL EQUATIONS

This information is beyond the scope of 7th graders, and is for VSVSer only.

The equations for the reactions that occur when anhydrous calcium chloride is added to the sodium bicarbonate solution are given below.

Sodium bicarbonate solid dissolves in water and separates into the 2 different ions: This is a physical change.

$$NaHCO_3 \rightarrow Na^+(aq) + HCO_3\ (aq)$$

The bicarbonate ion (HCO_3^-) is a weak acid and partially ionizes in solution.

$$HCO_3^-\ (aq) \rightarrow H^+\ (aq) + CO_3^{2-}\ (aq)$$

When water is added to calcium chloride, the solid dissolves and separates into the 2 different ions:

$$CaCl_2\ (s) \rightarrow Ca^{2+}\ (aq) + 2\ Cl^-\ (aq)$$

This reaction is exothermic, and is actually a chemical change. Anhydrous calcium chloride rehydrates and makes strong bonds with water. If a solution of calcium chloride and water is allowed to evaporate, the recovered compound is not chemically the same as the initial anhydrous calcium chloride

The calcium ion (Ca^{2+}) reacts with the bicarbonate ion (HCO_3^-) to form insoluble calcium carbonate and hydrogen ion (H^+).

$$Ca^{2+}\ (aq) + HCO_3^-\ (aq) \rightarrow CaCO_3\ (s) + H^+\ (aq)$$

The bag fills with carbon dioxide gas because the hydrogen ion formed in the reaction of calcium ion and bicarbonate reacts with remaining bicarbonate ion to give carbon dioxide gas. This is similar to the reaction that happens when vinegar is added to baking soda.

$$H^+\ (aq) + HCO_3^-\ (aq) \rightarrow CO_2\ (g) + H_2O\ (l)$$

The indicator changes color because the carbon dioxide dissolves in water to produce an acidic solution.

$$CO_2\ (g) + H_2O\ (l) \rightarrow H_2CO_3\ (aq) \rightarrow H^+\ (aq) + HCO_3^-\ (aq) \qquad (4)$$

Reference: *Fun With Chemistry*, Vol. 1, 2nd ed.; Sarquis M., Sarquis, J., Eds.; Publ. 91-005; Institute for Chemical Education, University of Wisconsin: Madison, 1991; pp 147-153.

Adapted by: Dr. Melvin D. Joesten, Department of Chemistry, Vanderbilt University
Pat Tellinghuisen, Director of VSVS

Your Notes:

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Answers: Explanations for Results of Experiments			
	Reactants	**Observations**	**Explanation**
Demonstration by VSVS team	H_2O plus phenol red solution	No reaction	None
Experiment 1 in test tube 1	$NaHCO_3$ plus H_2O	**$NaHCO_3 \rightarrow Na^+(aq) + HCO_3(aq)$** Solid is slightly soluble; final solution color is cloudy white; solution is colder. Temperature drops about 4° C	The temperature of the solution in the test tube decreases because baking soda absorbs heat when it dissolves in water. This reaction is **Endothermic.**
Experiment 2 in test tube 1	Add a squirt of phenol red to previous test tube	Solution color is cloudy pink/red	Color is pinkish because the red is mixing with a white cloudy solution
Experiment 3 in test tube 2	$CaCl_2$ plus H_2O	**$CaCl_2 \rightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)$** Solid dissolves into solution and forms a cloudy solution. Solution is warmer. Temperature increases by about 5°C.	Anhydrous calcium chloride gives off heat when it dissolves in water. **This reaction is Exothermic.**
Experiment 4 in test tube 2	Add a squirt of phenol red to previous test tube	Color is red.	Phenol red does not change color.
Experiment 5 in test tube 3	Solid $NaHCO_3$ plus solid $CaCl_2$	No reaction	None
Experiment 6 in test tube 3	$CaCl_2$ plus $NaHCO_3$ plus H_2O	Bubbles form; fizzing sound is heard; test tube is cold to touch; solution color is cloudy white. Temperature drops about 4°C	The test tube fills with carbon dioxide gas because the hydrogen ion (formed by ionization of bicarbonate) reacts with remaining bicarbonate ion to give carbon dioxide gas. There will be cold and hot spots, and the test tube continues to feel cold because heat is being absorbed. See equation below.
Experiment 7 in test tube 3	Add a squirt of phenol red to previous test tube	Color is yellow	The products of the reaction have formed an acidic solution

Instruction Sheet

Students work in groups of 3

A. Experiment in a Ziploc Bag

1. Hold the bag upright over the plate.

2. Open the bag while a VSVS member goes by and adds a teaspoon of calcium chloride.

3. Add the phenol red solution (includes water) to the bag and seal the bag.

4. **Gently** shake the contents of the bag while holding the bag over the plate.

5. Feel the bag (while keeping it upright) and record observations about color changes, temperature changes (is the bag cold or warm or both since there can be localized heating), changes in bag size, any gas given off or foaming.

6. The reaction takes about three to five minutes. During this time the student not holding the bag writes down all observations that the pair has made. Then, the students should switch. One should feel the bag and the other should write observations.

NOTE: There is no danger of the bag exploding if the correct amounts of chemicals are used. Since everything is pre-measured, you should have no problems. In the event one does explode or leak, use paper towels to clean up any mess. If you have followed directions, any spilled liquid will be on the plate, which can be easily wiped up with paper towels. Remember that the chemicals are safe.

B. Experiments to Determine the Roles of the Different Reagents in the Reaction .

1. Watch a VSVS member add phenol red solution to water. Record results.

2. Place the thermometer in an empty test tube for 30 seconds and then record temperature.

3. Add **TWO** small spoons of sodium bicarbonate ($NaHCO_3$) to the **FIRST** test tube and then add water (H_2O) so the tube is 1/3rd full. Stir with the stirrer and measure the temperature of the solution. Record observations in the Experiment 1 row.

4. Add a squirt of phenol red solution to the **SAME** test tube and record observations in the Experiment 2 row.

5. **Wipe the stirrer and thermometer with the tissue. Use a clean new spoon for the next step.**

6. Add **ONE** small spoon of calcium chloride ($CaCl_2$) to the **SECOND** test tube and then add water (H_2O) so the tube is 1/3rd full. Stir with the stirrer and measure the temperature of the solution. Record observations in the Experiment 3 row.

7. Add a squirt of phenol red solution to the **SAME** test tube and record observations in the Experiment 4 row.

8. Add $NaHCO_3$ plus $CaCl_{2\,t}$ to the **THIRD** test tube. Does anything happen? Record observations in the Experiment 5 row.

9. Add water (H_2O) to the same test tube so the tube is 1/3rd full. Stir with the stirrer and measure the temperature of the solution. Record observations in the Experiment 6 row.

10. Add a squirt of phenol red solution to the **SAME** test tube and record observations in the Experiment 7 row.

Record the room temperature _____

Observations of Experiments			
	Reactants	**Observations**	**Explanation**
Demonstration by VSVS team	H_2O plus phenol red solution		
Experiment 1 in test tube 1	$NaHCO_3$ plus H_2O	$\mathbf{NaHCO_3 \rightarrow Na^+(aq) + HCO_3\ (aq)}$	
Experiment 2 in test tube 1	Add a squirt of phenol red to previous test tube		
Experiment 3 in test tube 2	$CaCl_2$ plus H_2O	$\mathbf{CaCl_2 \rightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)}$	
Experiment 4 in test tube 2	Add a squirt of phenol red to previous test tube		
Experiment 5 in test tube 3	Solid $NaHCO_3$ plus solid $CaCl_2$		
Experiment 6 in test tube 3	$CaCl_2$ plus $NaHCO_3$ plus H_2O		.
Experiment 7 in test tube 3	Add a squirt of phenol red to previous test tube		