TEACHER GUIDE
Chemical Science

LEARNING UNDEFEATED
Educate | Elevate | Empower

Wait, Weight?

Topic(s): Chemistry

Grade level(s): 6th-8th grades

Time: One class period, 50-60 minutes

NGSS Alignment: MS-PS1-5

TEKS Alignment: 6.5C, 7.6, 8.5E

ACTIVITY OVERVIEW

This activity dives into physical and chemical changes by having students learn and investigate the clues of each. Physical and chemical changes can be difficult concepts to teach students due to differences happening at the molecular level. This lab activities will allow students to see the differences between physical and chemical changes that challenge their observations and understandings.

This lab is part of the chemical science unit which is broken up into three lab activities. The first activity, What's in a Change?, works well as an introduction to chemical and physical changes that allows students to observe physical and chemical properties before and after two reactions: dry ice with water and acetic acid with calcium carbonate. To follow up on these ideas and concepts, we recommend trying our second and third activity of the unit. The second lab activity, Mixing Things Up, centers around solubility and mixtures and will challenge students to determine whether creation of a powdered drink mix is a physical or chemical change. The third activity, Wait, Weight?, will challenge students' understanding of the law of conservation of mass and have them collect data to support its viability for both physical and chemical changes.

Table of Contents

ALIGNMENT TO STANDARDS

NGSS:

MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

TEKS:

6.5C. Identify the formation of a new substance by using the evidence of a possible chemical change such as production of a gas, change in temperature, production of a precipitate, or color change.

7.6. Distinguish between physical and chemical changes in matter.

8.5E. Investigate how evidence of chemical reactions indicates that new substances with different properties are formed and how that relates to the law of conservation of mass.

LEARNING OUTCOMES

Students will know:

- The law of conservation of mass
- The common examples of physical change: color, shape, change of state, texture, density
- The common examples of chemical change: change in temperature, change in color, noticeable odor after reaction, formation of a solid, formation of a gas.
- Solutions are the result of a physical change

Students will understand:

- Appearance or form of matter changes in a physical change, but not the kind of matter in a substance, i.e. ice to water.
- Kind of matter changes in a chemical change and at least one new product or substance with NEW properties is formed, i.e. baking soda and vinegar create sodium acetate and carbonic acid, which then turns into carbon dioxide.
- Matter of different types will have different physical and/or chemical properties
- What they do in this lab are the same skills needed in STEM careers.

Students will be able to:

- Observe and model the law of conservation of mass
- Distinguish between physical and chemical changes in matter.
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CAREER CONNECTIONS

Chemical Technician

Chemical technicians use special instruments, equipment, and techniques in research labs to assist chemists and chemical engineers.

Work Environment: Chemical technicians can usually be found in laboratories or manufacturing facilities.

Duties: Professionals in these jobs have the following duties and more: monitor chemical processes, test quality of products, setup and maintain lab equipment, troubleshoot problems, prepare chemical solutions, run experiments, analyze and interpret data results, prepare reports, and give presentations.

Median Salary: $48,160 (US Bureau of Labor, 2018)

Food Chemist

A food chemist researches foods and their ingredients for improvements. This research could range from examining the balance of ingredients in different foods to improve the taste to testing the quality of foods to ensure safety for human consumption before production and sales.
Work Environment: Many food chemists work in laboratories and offices. Many food chemists work for the United States Food and Drug Administration, a federal agency.

Duties: Professionals in these jobs have a number of duties, such as testing food or drink samples to ensure they follow federal guidelines, observe quality of processing of food, and analyze ingredients to offer accurate nutritional information.

Median US Salary: $64,020

Source: https://www.bls.gov/ooh/life-physical-and-social-science/agricultural-and-food-scientists.htm

Geochemist

A geochemist specializes in research that improves the quality of essential things for natural life, such as oil, minerals, and water. Geochemists often explore the history of the earth and its changing conditions.

Work Environment: Many geochemists work mainly outdoors. They are typically employed by oil companies, universities, and research institutes.

Duties: Professionals in these jobs have a number of duties, such collecting environmental samples for quality testing, analyzing data for quality improvement, and writing reports and presenting them to other scientists or elected officials in a community.

Median US Salary: $91,130

Source: https://www.bls.gov/ooh/life-physical-and-social-science/geoscientists.htm

Materials Scientist

A materials scientist examines natural and man-made substances to document their composition, properties, and how the quality can be most efficient.

Work Environment: Many materials scientists work in manufacturing facilities and laboratories. Many of these professionals are employed by technology manufacturing facilities.

Duties: Professionals in these jobs have a number of duties, such as examining chemical properties of different materials, testing the quality of materials, and creating materials to improve a specific model.

Median Salary: $78,330

Source: https://www.bls.gov/ooh/life-physical-and-social-science/chemists-and-materials-scientists.htm

Chemical Engineer

Chemical engineers apply chemistry, biology, physics, and math to solve problems involving the use of chemicals. This includes areas like fuel (biodiesel), drugs (vaccines), and food (GMOs).

Work Environment: You can find chemical engineers working in the office or in laboratories. You may also find them directly at work sites like an industrial plant or refinery to monitor and ensure operations run smoothly.

Duties: Chemicals engineers are involved in a wide range of duties. These include conducting research, designing and planning the layout of instruments and equipment, conducting tests and monitoring performance, developing processes for step-by-step use, and much more. They can be responsible for overseeing entire projects or very specific processes within a project.

Median Salary: $104,910 (US Bureau of Labor, 2018)

What's in a Change? (1 class period)

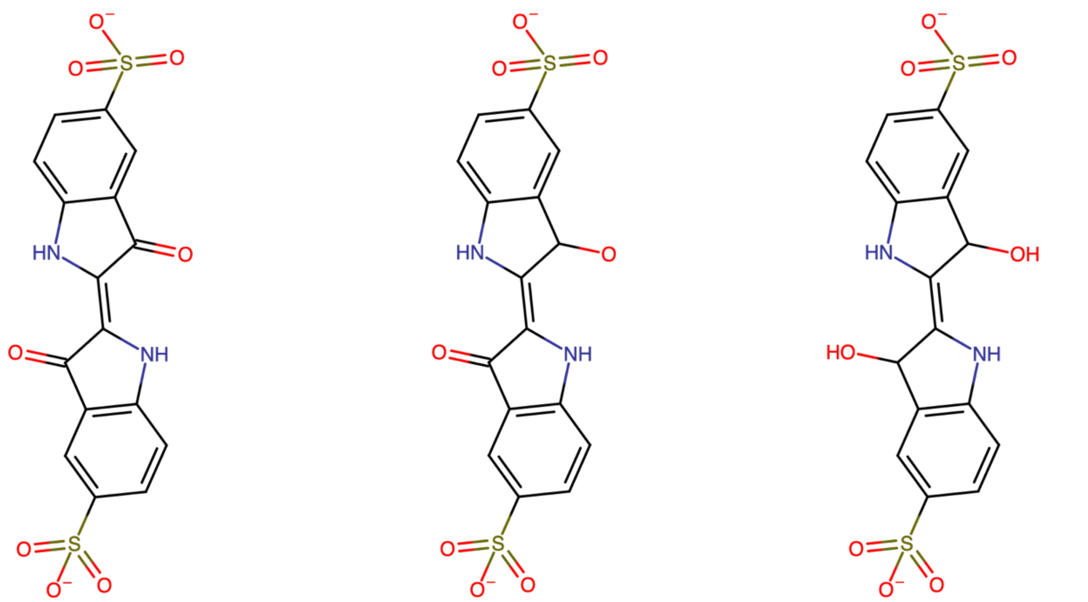
BACKGROUND INFORMATION

In this activity, students will study the effect of chemical and physical changes on mass. The reaction students will view is commonly termed the traffic light reaction because of its color progression from green to red and then to yellow.

Students will use the reaction to determine the validity of the law of conservation of mass for physical and chemical changes alike. The law of conservation of mass states that the mass of a system cannot change in a chemical reaction. In other words, the total mass of the reactants of a reaction will be the same as the total mass of the products.

Students will observe the physical change of adding dye to water and then a chemical reaction which will reduce the dye. The dye used in the reaction, indigo carmine, is a bright blue color when dissolved in distilled water. This color is associated with the dye's oxidized form. When in the presence of a base, like NaOH, the dye starts to reduce. When reduced, the indigo carmine is yellow in color. The ascorbic acid in the solution slowly reacts with the dye to reduce more and more allowing for the observed color change.

Indigo Carmine Structures



Oxidized (blue) **Semi-Reduced (red)** **Fully Reduced (yellow)**

The color change comes from the different amounts of the molecules above. For example, in distilled water the solution is blue but at a high pH the solution turns green. This is because the base reduces some of the dye to yellow: yellow and blue combine to make green. Then the solution turns from green to red as more of the semi-reduced indigo is made. Finally, the solution ends in yellow because all of the present dye in the solution has reached its fully reduced state.

For more information about the chemistry of this reaction, we recommend reading the following article from the Royal Society for Chemistry. Please note, that this article discusses a version of the reaction that uses glucose as the reducing agent while our reaction will utilize ascorbic acid.

Fleming, D., 2014. *Beyond the 'blue bottle'*. [online] Royal Society of Chemistry. Available at: https://edu.rsc.org/exhibition-chemistry/beyond-the-blue-bottle/2000041.article

Physical and chemical change

- https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Fundamentals/Chemical_Change_vs._Physical_Change

Law of Conservation of Mass

- https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Book%3A_The_Basics_of_GOB_Chemistry_(Ball_et_al.)/05%3A_Introduction_to_Chemical_Reactions/5.1%3A_The_Law_of_Conservation_of_Matter

Science of the Chemical Traffic Light Reaction

- https://www.youtube.com/watch?v=1ueSa6-UqYo

REAGENT PREPARATIONS

Indigo Carmine

- On a weigh boat, add a small amount of indigo dye (approximately 3 mg)
    - Amount should be less than 0.01g, use photo for reference of amount. Too much dye will result in darker solutions and will make it harder to observe color changes.
- Repeat for each needed student station.

Ascorbic Acid Solution

- To a 1L bottle, combine the following:
    - 0.93g ascorbic acid ($C_6H_8O_6$)
    - 0.25g sodium bicarbonate ($NaHCO_3$)
    - 1.67 g sodium chloride (NaCl)
    - 0.0078 g copper sulfate ($CuSO_4 \cdot 5H_2O$)
    - 1000mL distilled water
- Stir with magnetic stirrer until completely dissolved
- Aliquot 50mL in appropriately labeled 50mL conicals
- Shelf life- 1 week

Sodium Hydroxide Solution (0.13M)

- To a 1L bottle, combine the following:
    - 5.06 g sodium hydroxide pellets (NaOH)
    - 1000mL distilled water
- Stir with magnetic stirrer until completely dissolved
- Aliquot 50mL in appropriately labeled 50mL conicals
- Shelf life- indefinite

STUDENT STATION SETUP

Each station accommodates 2 students who will work on the activity as a pair.

1. Paper towel (optional)
2. Ascorbic Acid Solution
3. Sodium Hydroxide Solution
4. Weigh boat of indigo carmine
5. 50mL graduated cylinder
6. 125mL flask with stopper or 60mL screw top bottle
7. Scale (can be shared with up to 3 groups)

CHEMICAL DISPOSAL

At the end of class, each student group can dispose of their reaction mixture in a gallon sized container. To neutralize the solution, add 3.5mL of vinegar per 50mL (amount disposed by each group). After adding vinegar, the solution can safely be poured down the sink.

LESSON PLAN

Slide 1: Wait, Weight?

- Introduce today's activity about types of mixtures while passing out the *Wait, What About Weight?* worksheet. Have students read the activity introduction while the class settles in.

Slide 2: Learning Objectives

- Explain to students that at the end of today's activity, they will have done the following:
  - Measure the mass of reactants and products
  - Determine the validity of the law of conservation of mass for physical and chemical changes

Slide 3: Chemical Equations

- Explain to students that one way to describe and communicate the changes in a chemical reaction is with a chemical equation. A chemical equation is a written representation of the rearrangement of the atoms in the reaction. The reactants are written on the left side of the arrow (*Advance slide to show reactants side of equation)* and the products are listed on the right side of the arrow (*Advance slide to show products side of equation)*. Explain that each molecule lists the component element types and how many are present through the use of subscripts. *Advance slide to circle subscripts, advance again to remove circles.*
- Ask students to think about the chemical reaction between baking soda (sodium bicarbonate) and vinegar (acetic acid). Ask students if they know what one of the products of that reaction are.
  - Bubbles are formed and it is composed of carbon dioxide gas.
- Call students' attention to the chemical equation on the slide and ask students to record the number of each type of element for the reactants and the products.
  - Students may record their results on their worksheet as the table is filled out on the slide as a class.

	Reactants	Products
Sodium (Na)	**1**	**1**
Hydrogen (H)	**5**	**5**
Carbon (C)	**3**	**3**
Oxygen (O)	**5**	**5**
Total atoms	**14**	**14**

- Explain to students that these equations are always balanced, meaning there are the same number of atoms and specific element atoms on the reactant side as there are on the product side.

Slide 4: Law of Conservation of Mass

- Explain to students that in order to know these chemical equations have to be balanced, scientists had to develop investigations to see how mass would change after a physical or chemical change.
- These scientists, including Antione Lavoisier, would carefully measure the mass of the reactants and products in closed chambers to ensure that all gas was sealed in and could not escape.
- Through their studies, they discovered the law of conservation of mass which states that the mass before and after a chemical reaction will always be the same. This is because

the total number of each type of atom is conserved and therefore the mass cannot change.

Slide 5: Today's Investigation

- Introduce students to the main question of today's activity: is mass conserved in physical and chemical changes?
- Break students into groups of two to three and assign each group a station in the laboratory/classroom.
    - *Teacher's Note: Students will work on their worksheets, but have their responses recorded collectively through the slides.*

Slide 6: Part 1 Ascorbic Acid Solution and Indigo Carmine

- Review the procedure for Part 1 "Ascorbic Acid Solution and Indigo Carmine". Ensure students are measuring their combined masses with both the indigo carmine and ascorbic acid solution on the scale.
- Review and record collected data in the table on the slide.
- If time allows, review the "Quick Check" questions with students.
    - Indigo carmine is soluble in water. With this information, what kind of change contributed to the observed color change? Why
        - *The color change was due to a physical change because the indigo carmine is soluble meaning that the indigo carmine molecules dissolved and completely surrounded themselves with water molecules. All of the molecules are unchanged, but the indigo carmine is now floating in the solution.*

Slide 7: Part 2 Ascorbic Acid-Indigo Carmine and Sodium Hydroxide

- Review the procedure for Part 2 "Ascorbic Acid-Indigo Carmine and Sodium Hydroxide". Ensure students are measuring their masses with the test tube of sodium hydroxide in the flask of ascorbic acid-indigo carmine solution.
- Review and record collected data in the table on the slide.
- If time allows, review the "Quick Check" questions with students.
    - Does the NaOH cause a physical or chemical change with the ascorbic acid-carmine solution? How do you know?
        - *A chemical reaction, the color changes due to the molecules interacting and rearranging. If it was a physical change, we would expect the clear solution of sodium hydroxide to dilute the color of the blue indigo carmine dissolved in the ascorbic acid solution.*
    - Does the change result in a change in mass? Why not?
        - *The mass does not change. The molecules that are present in the beginning are rearranged to create new molecules that appear as different colors.*
    - This reaction is reversible. Shake the flask and record what happens. What could the solution be reacting with? How could you test your hypothesis?
        - *As the flask is shaken, the color turns from yellow, back to red, and eventually back to green.*
        - *Teacher's Note: Student hypotheses might vary. The science of the reaction is that the introduction of oxygen allows the reaction to reverse. To test this the reaction could be tested in a vacuum or in a chamber filled with a specific gas type to ensure that it is oxygen that allows the reverse reaction.*

Slide 8: Lab Clean Up

- Have students clean their station before leaving at the end of the class.