Fifth Grade Physical Science

Classroom Detective Agency: Chemical Changes

Background Information

Students are introduced to the differences between physical and chemical changes in simple kitchen substances that react to water and indicators in characteristic ways. The observable clues that a physical change has occurred includes changes in state such as gas, liquid, or solid. The material itself is the same before and after the change. An ice cube melting is an example of a physical change.

A classic observable clue that a chemical change has occurred is a color difference. This occurs when new kinds of matter are formed. The composition changes and the new kinds of matter have different properties from the old matter. The substances present at the beginning of the change are not present at the end; new substances are formed. The change cannot be “undone." Evidence of a chemical change may include production or use of energy such as heat or light, the new production of a gas or solid, or a change in color.

The five mystery powders in this activity have different physical properties (texture, grain size) even though they are all white. They react differently with other substances like red cabbage solution. Students will collaboratively explore how someone might discern one powder from another. The observations gathered is then be used to analyze and interpret data and engage in argument from evidence about what the mystery powder is.

Students will also test the powders in water solutions with litmus and pH paper. These test strips are used to identify whether a chemical is acidic, basic or neutral. The pH scale, which ranges from 0 to 14 are used in many chemical applications measure but also affects most life forms. For example, a slight change in the soil’s pH can kill plants, water pH is important for all forms of aquatic life and small changes in the pH of the human body can cause health problems.

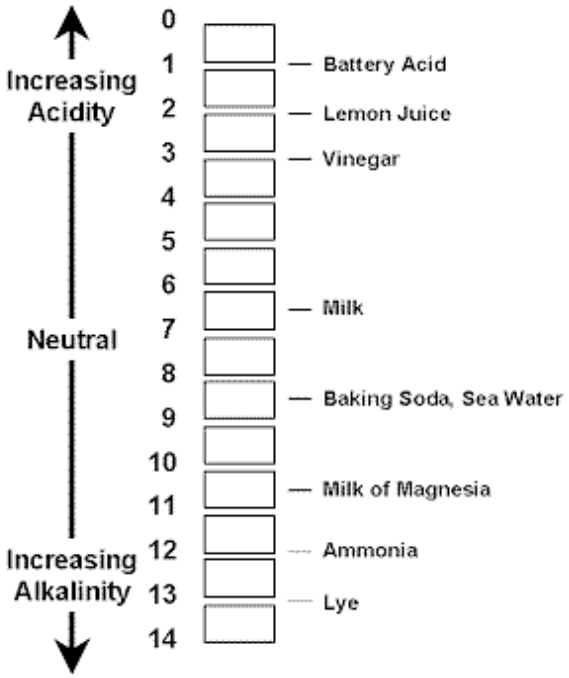
pH is a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units". Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of five is ten times more acidic than water having a pH of six.

Acids and bases neutralize each other because mixing them changes the relative concentrations of positive and negative ions. So, if you add baking soda (a base) to vinegar (an acid), the mixture’s pH will move closer to 7 (the neutral point on the pH scale).

Low pH values are considered acidic, high values are called basic and values around 7 are neutral. Common substances and their pH levels include:

- Bleach (13)
- Soapy water (12)
- Baking soda (9)
- Pure water (7)
- Black coffee (5)
- Lemon juice (2)

Both Litmus paper and pH strips are small strips of paper coated with a chemical substance that will undergo a reaction when it comes in contact with the liquid being tested. Litmus paper comes in two colors: red or blue. Red Litmus paper turns blue if it comes in contact with a base, alternatively blue litmus paper turns red with acids. This is a pass or fail type of test that only works with acidic or basic liquids. Neutral solutions do not cause a change of color. Litmus paper is a rough estimate of pH but pH test strips are compared to a chart to give a more precise determination of whether the liquid is acidic, basic, or neutral.



Red cabbage contains a chemical called anthocyanin that changes color depending on the acidity of its environment. In an acidic environment it is reddish-pink, in a neutral environment it is purple, and in a basic (or alkaline) environment it turns bluish-green.

Blueberries contain the same anthocyanin and also turns pink in an acidic environment. In a basic (alkaline) medium, it will turn dark blue or even black.

Performance Expectation: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances. https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/5-PS1-4%20Evidence%20Statements%20June%202015%20asterisks.pdf

Disciplinary Core Idea

PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

Science and Engineering Practices

Planning and carrying out an investigation: Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered

Engaging in argument from evidence: Identify the evidence that supports particular points in an explanation

Cross cutting concept

Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

Materials

- Salt (fine grain)
- Sugar (confectioners/powdered)
- Baking soda
- Cornstarch
- Flour (white)
- Magnifiers
- Tape
- pH paper
- Water
- Plastic pipettes or eye droppers
- Coffee stirrers
- Litmus paper
- Cups
- Spoons
- Safety goggles.
- Reaction plates (clear polystyrene plates organized into rows of wells.)
- Aluminum foil
- Red cabbage or blueberry indicator

Advance Preparation

- Choose an item from your classroom that you will hide until after the students have determined the answer to the mystery.

- Label 6 cups “baking soda, salt, cornstarch, flour, sugar and mystery”. Confectioners (powdered) sugar works well because it similar to the other powders. You will need to decide which substance you will use for the mystery powder. You might want to use baking soda as the mystery powder because it will give a clear color test result with red cabbage or blueberry solutions. Alternatively, use cornstarch or sugar; something that has a clear pH change with the addition of solutions. Be sure the testing strips (red and blue

litmus paper, pH paper) are marked and provide marked containers of water and red cabbage or blueberry indicator.

- To prepare the red cabbage indicator, chop up ¼ head of cabbage and place in a bowl. Cover with 2 cups boiling water and let steep for 20 minutes. Drain off the liquid and let cool. Alternatively, you can place chopped up red cabbage in a zip-closing bag, add at least 1 cup of warm water and squish around until the liquid turns medium to dark blue. Open a corner and drain the liquid into a cup. If you want to use blueberry indicator, roughly chop ½ c blueberries and add 2 cups boiling water. Let steep for 20 minutes and strain the liquid into a bowl to cool. To get a more intense color and reaction, cook the blueberries until soft and then strain.

Objectives The student will be able to:

- Plan and conduct an investigation to describe and classify different kind of materials by their observable properties.
- Students will learn that a physical change happens when some properties change (such as shape), but the material itself is the same before and after the change. The change can be undone.
- Students will learn that a chemical change occurs when a substance present at the beginning of the change are not present at the end; new substances are formed. The change cannot be undone.
- Students will be able to compare and classify the properties of compounds.
- Students will use appropriate tools to conduct a scientific investigation.
- Students will produce a piece of writing which is appropriate for a scientific investigation and the task assigned.

Resources

- https://www.learner.org/courses/essential/physicalsci/session4/closer1.html
- https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/safetypractices/safety-in-the-elementary-school-science-classroom.pdf
- https://water.usgs.gov/edu/ph.html

Suggested Implementation

Formative assessment - Ask students a series of questions about some simple physical and chemical changes that they have seen. Here are a few examples. You might start with the aluminum foil to get the conversation started. Record and post the examples.

Physical changes:

- 12” by 12” square of aluminum foil. If you cut it in half have you changed the composition of the foil? If you roll it in a ball, does that change the composition?

- Melting ice cube.
- Ball of clay. If you roll it out, has the composition changed?
- Butter melting on toast. Once it is melted, has it changed composition?
- Water evaporating from a glass. Where did the water go? Did it change in composition?
- A juice box that gets frozen.

Chemical changes:

- Milk goes sour
- Jewelry tarnishes
- Bread become toast (or burns)
- Rust forms on a nail
- Food scraps are turned into compost in a compost pile.

These videos are great to help students understand chemical and physical changes.
https://www.youtube.com/watch?v=37pir0ej_SE
and the basics of matter, including physical change.
https://www.youtube.com/watch?v=wyRy8kowyM8&list=PLUBFfN1xMv-reQ7ka86qw42IGE4asptaC

Set the scenario for the class.

Students enter the classroom and you tell them that an object is missing (picture, flag, something off of the teacher's desk.) It is possible that someone came into the classroom overnight and stole the object. The only evidence left behind was a mysterious white powder. People with access to the room at night are the custodian who used **baking soda** to clean crayon marks off a wall**,** the principal who has a fondness for powdered **sugar** donuts), the assistant principal who used **salt** to clean out stains in her coffee mug, the science teacher who stayed late to grade student projects made with **corn starch**, and the art teacher who made clay out of **flour**. The students will use their skills as scientists to identify the unknown powder and write a letter to a "judge" presenting the evidence and requesting the object be returned.

Explain they will be developing experiments in order to crack the case of the five mystery powders. Show students the unknown powders and let them speculate what they think they might be. Warn students of the dangers of tasting unknown substances. Students will describe the powders' physical properties on the recording sheet by describing color and texture. Students will then develop a hypothesis of what they think each mystery powder is. Students will record their hypotheses on their student handout. Have students share their hypotheses and ask students what tests they could do to find out about each powder.

The student handout includes a list of safety considerations. Even though these substances are commonly found in kitchens, they are harmful if the powders get in the eye. Students must not

be allowed to use "taste" were allowed would be that the substance known as salt tastes "salty" and the substance known as sugar would taste "sweet". Tasting "unknown substances" is not advised in science classrooms at any age level.

Print out extra pages of the data sheet (page 3 of the student handout). These can be used under the Chem plates to permit easy identification and eliminate the need to mark the plates.

Students will mix each of the mystery powders with water and other testing agents to discover what happens and record their observations on their recording sheet.

Powder	pH	Reaction to Water	Red and Blue Litmus Paper	Reaction to Red Cabbage solution and pH	Reaction to Blueberry solution and pH
Cornstarch	7	Cloudy	Red No change Blue No change	Faint blue color pH 5	Pink color pH 5
Salt	5	Dissolved	Red No change Blue No change	Faint blue color pH 5	Pink color pH 4
Flour	6	Cloudy	Red No change Blue No change	Lavender color pH 5	Pink color pH 4
Baking Soda	8	Slightly cloudy	Red turned blue Blue No change	Aqua blue color pH 7	Black color pH 8
Sugar	6	Dissolved	Red No change Blue No change	Faint blue color pH 5	Pink color pH 4

Students will draw a conclusions about each powder based on their investigations and then write an evidence-based argument about the identity of the mystery powder and who the culprit might be.

Debrief

- What is the identity of the mystery powder and what evidence do you have to support that?
- What are some properties of matter that can be used to identify an unknown substance?
- How can you determine the identity of an unknown substance using known substances like indicator and test papers?
- What is the difference between physical properties and chemical properties of matter?

Assessment

A sample scoring rubric is below that can be used to review the letter to the judge.

	10 points	5 points	0 points
Identity of the Unknown	Mystery powder is identified as one of the knowns	N/A	Mystery powder is not identified
Evidence	Clear evidence from at least 3 tests is used to identify the mystery powder	Evidence from at least 2 tests has been mentioned	Evidence from 1 test has been mentioned
Identifies the Suspect	Scenario is referenced and accurately identifies the suspect related to the known substance	Letter accurately identifies the suspect related to the known but does not reference the scenario	Scenario and suspect are not referenced
Letter format	Letter is written appropriately; sentence structure is appropriate	Letter has some minor style issues	Not written as a letter
Grammar and spelling	Grammar and	Letter has some minor grammar or spelling issues	Grammar and/or spelling has many errors

Accommodations

Visually impaired students will need assistance in interpreting the results of some of the tests. Their contribution to data collection could be in describing the texture and smell of the substances. Students with cognitive disabilities may have a different rubric for their final letter (as determined by the teacher).