Yellow/Blue Switcheroo

Through an exciting experiment, students are introduced to the steps of the scientific method and apply their knowledge to make hypotheses and detailed observations.

Grade Level: 1st

Phenomena:
Using the scientific method helps scientists conduct and carry out experiments.

Objectives:
- Students will discuss steps of the Scientific Method.
- Students will predict outcomes of a set experiment
- Students will evaluate the importance of following safety procedures while experimenting
- Students will draw conclusions based on the outcomes of a set experiment
- Students will create an illustration showing steps in the Scientific Method

Materials:
- Hydrogen peroxide solution, potassium iodate, sulfuric acid, soluble starch, malonic acid, manganese (II) sulfate, water (distilled or deionized)
- *Or pre-made solutions (with mixtures and concentrations needed) can be purchased from Flinn Scientific, Inc.*
- Graduated cylinders - 3
- Beaker, stir stick, rubber gloves, goggles
- *The Scientific Method* song

Appendixes:
- *The Scientific Method* song: Page 4

Time Considerations:
Preparations: 15-20 minutes
Lesson Time: 45-60 minutes
Introduction: 15 minutes
Activity 1: 15-20 minutes
Conclusion: 15-20 minutes

Related Lesson Plans:

Nevada Outdoor School . org

Next Generation Science Standards

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

Science and Engineering Practices (SEP):
Planning and Carrying out Investigations.

Disciplinary Core Ideas:
Structure and Properties of Matter

Crosscutting Concepts
Patterns

Excellence in Environmental Education Guidelines

Strand 1— Questioning, Analysis and Interpretation Skills
A) Learners are able to develop questions that help them learn about the environment and do simple investigations.

C) Learners are able to locate and collect information about the environment and environmental topics.

This lesson has been adapted from Flinn Scientific, Inc.'s *The Yellow and Blue Switcheroo*:

Flinn Scientific, Inc. (2010). The Yellow and Blue Switcheroo. *Chem Fax!, 8660*

Background

Students will think you are the master of chemistry when you do this exciting demonstration. Three colorless solutions are mixed to produce a yellow solution which suddenly turns blue and then yellow again. The solution will oscillate between yellow and blue for several minutes. This oscillating reaction is known as the Briggs-Rauscher (BR) reaction and was developed by Thomas S. Briggs and Warren C. Rauscher of Galileo High School in San Francisco. The reaction mechanism is very complex. During the reaction, oscillations occur in the concentrations of iodine and iodide ions. The yellowish color is attributed to the rise in I_2 concentration; the blue/black color of the starch-iodine complex results from the rise in both I^- and I_2 concentrations. The colorless solution is caused by the decline in I_2 concentration and the continued rise in I^- concentration.

The dark blue starch iodine complex is amylase-iodine. The dark blue color comes from the pentaiodide anion, I_5^- formed when I_2 and I^- concentration are elevated. Though normally an unstable anion, it becomes stable as a part of the starch complex.

These two reactions are very complex, consisting of ten steps. Iodine (I_2) and iodide ions (I^-) are produced as

intermediates in various steps along the reaction pathway. In the reaction mechanism, the concentration of HOI rises and falls, triggering oscillations in the I^- and I_2 concentrations in solution. When I_2 and I^- concentrations are high, the solution is blue; when I_2 and I^- is low, the solution is yellow; and when I_2 is low and I^- is high, the solution is clear. The oscillations continue until either malonic acid or iodate ions are consumed.

This advanced chemical reaction will be used as a tool to introduce the scientific method and importance of making precise and accurate observations to students.

The scientific method is a process for experimentation that is used to explore observations and answer questions. Scientists use the scientific method to search for cause and effect relationships in nature. Conclusions are reached through asking questions, formulating guesses, creating and performing experiments, and analyzing the result (*Science Buddies).*
If you have purchased pre-mixed solutions, then skip ahead to “doing the activity”.

How to Prepare Solutions:

Preparation

Prepare 8.6% hydrogen peroxide solution by adding 29 mL of 30% H_2O_2 to distilled water and diluting to 100mL.

Prepare 0.2M potassium iodate acidified solution by adding 10 mL of 1M sulfuric acid H_2SO_4, to 90 mL distilled water. Add 4.3 g KIO_3 and stir to dissolve.

Prepare a starch-malonic acid-manganese (II) sulfate solution by boiling 100 mL of distilled water. Add 0.1g soluble starch to 5 mL of the boiling water. Stir. Add the starch paste to the remaining boiling water while stirring.

Boil for five more minutes. Allow the solution to cool.

Add 1.5g malonic acid and stir. Add 0.4g manganese (II) sulfate, $MnSO_4 \cdot H_2O$.
Introduction:
Ask the students if they have ever done an experiment before. If so, what did they do? What were they trying to find out? What did they use to carry out the experiment?

Before doing the experiment, ask students if they have heard of the scientific method; briefly go over the steps and what they entail.

1. Question: When scientists do experiments, they always begin with a question.

2. Hypothesis/Prediction: After asking the question scientists then try to guess the answer.

3. Research: Randomly combining things from around the house is dangerous so scientists have to do some research by reading, looking on the internet or asking other scientists.

4. Experiment: This is generally the fun part. Scientists do an experiment by following the directions and they have fun! But they are always safe and careful.

5. Results: Scientists keep accurate records of results of their experiment.

6. Conclusion: Examine the meaning of your results.

Teach students *The Scientific Method* song. After going over the song, have students sing it with you.

Doing the Activity

Explain that you have three clear liquids that you will combine; ask the students what they think will happen. At this point they are making a hypothesis.

Activity 2: Experiment!
While conducting the experiment wear latex gloves and safety goggles. Have students evaluate the importance of scientists wearing proper clothing and following directions safely while experimenting.

As you do the experiment, tell students which step of the scientific method you are on and why.

Experiment Procedure

Use a 50 mL graduated cylinder to measure out 40 mL of 8.6% hydrogen peroxide solution and transfer it to a 250 mL beaker.

Fig. 1. Experiment oscillates between yellow

Use a clean 50 mL graduated cylinder to measure out 40 mL of the 0.2M potassium iodate acidified solution and add it to the beaker. Stir using a stirring rod or magnetic stirrer.

Use the third 50 mL graduated cylinder to measure out 40 mL of the starch-malonic-acid-manganese (II) sulfate solution. Add this solution to the beaker and stir.

Bubbles will begin to appear. In a short period of time, the solution will turn to yellow and then to blue and then to colorless. The yellow to blue to colorless oscillation will continue for about 10 minutes.

You may use different quantities of the liquids as long as the amounts of all three liquids are equal to each other.

Ask the students what they observed. Did the results surprise them? Were any of their hypotheses accurate? Remind the students that it does not matter whether their guesses were right, because the reason for conducting experiments is to find out the answer to a question.

Conclusion

Review the steps of the scientific method and the steps that were done in the experiment that was conducted: hypotheses, materials, experiment, conclusions, etc.

Assessment

Have students draw a picture of their favorite part of the experiment and write which step of the scientific method their favorite part took place during.

Vocabulary

Conclusion: a decision or answer, based on facts

Hypothesis: an educated guess

Materials: the tools and other things needed to perform a particular task

Results: the outcome(s) of a certain task or procedure

Scientific Method: the system of advancing knowledge by formulating a question, collecting data about it through observation and experimentation, and testing a hypothetical answer

Sources

- Flinn Scientific, Inc. (2010). The Yellow and Blue Switcheroo. *Chem Fax!, 8660*
- Science Buddies. (2010). *Steps of the Scientific Method.* Retrieved Aug. 26, 2010, from http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml

Images:

Fig. 1. Science Fair 2010. *Ossilating*. Retrieved Aug. 30, 2011, from http://fair2010.christnagar.org/fair-2010/exhibition/sample-projects/oscillating-clock-demonstration/

The Scientific Method

To the tune of: *The Wheels on the Bus*

There are six cool steps in the scientific method
The scientific method
The scientific method
There are six cool steps in the scientific method
When we do an experiment!

First we need to ask a question
Ask a question
Ask a question
First we need to ask a question
When we do an experiment!

Second we need to predict an outcome
Predict an outcome
Predict an outcome
Second we need to predict an outcome
When we do an experiment!

Third we need to gather materials
Gather materials
Gather materials
Third we need to gather materials
When we do an experiment!

Fourth we need to follow directions
Follow directions
Follow directions
Fourth we need to follow directions
When we do an experiment!

Fifth we need to look at the results
Look at the results
Look at the results
Fifth we need to look at the results
When we do an experiment!

Sixth we need to wrap it all up
Wrap it all up
Wrap it all up
Sixth we need to wrap it all up
When we do an experiment!!!