

Scientific Inquiry: Measurement/Data

Strand Scientific Investigation

Topic Investigating measurement

Primary SOL CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include

- d) manipulation of multiple variables, using repeated trials;
- e) accurate recording, organization, and analysis of data through repeated trials.

Background Information

Chemistry students should have a complete understanding of experimental design and the terminology involved. Students should know and be able to apply the following terminology:

variable—a factor that is changed in an experiment.

independent variable—the variable that is purposely changed. Each change of a variable is known as a *level* of independent variable.

dependent variable—the variable that changes as a result of changing the independent variable.

hypothesis—a predication about how changing the independent variable will affect the dependent variable. Hypotheses are based on observations, previous experimental results, information from books, and communication with other scientists. A hypothesis is usually an if/then statement in the following form: “If the (independent variable) is (name the change), then the (dependent variable) will (name the effect of the change).” When the hypothesis and the experimental results agree, the hypothesis is supported by the results; when the hypothesis and the experimental results do not agree, the hypothesis is not supported by the results.

constants—the various factors in an experiment that do not change.

control—an unmanipulated group that is the standard for comparison in an experiment.

data—information collected from the experiment. Data can be a collection of measurements or counts. Measurements are taken using instruments of the metric system. There is no such thing as a perfect measurement or a measurement that is free from error.

repeated trials—the number of times each *level* of the independent variable is tested.

Repeated trials are conducted to reduce the effect of errors and thus increase the reliability of the results of an experiment. The greater the number of repeated trials, the more confidence you can place in your data when you say that the hypothesis was or was not supported.

average (mean)—the sum of measurements or counts divided by the number of trials. When repeated measurements or counts are made, you summarize the data by finding the average or mean.

Materials

Demonstration materials:

- Two 250-mL beakers
- Warm tap water
- Red food coloring
- Dropper
- Bleach (sodium hypochlorite 5%)
- Safety goggles

Laboratory materials per group:

- Four antacid tablets
- Two 250-mL beakers
- Forceps
- Stopwatch
- Safety goggles

Vocabulary

average (mean), constants, controls, data, hypothesis, repeated trials, variable, independent variable, dependent variable

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Before class, fill two clear 250 mL beakers with 125 mL of warm water. Add one drop of red food coloring to one beaker. Add three or four drops of household (sodium hypochlorite) bleach to the other beaker.

Introduction

1. Show students the two beakers, and ask them what they think is in each of them. List their answers on the board.
2. After students have given you various answers, mix the two solutions, and note the reaction. Ask students to make some observations about what they saw happen.
3. Facilitate a class discussion until students arrive at the conclusion that sodium hypochlorite is a chemical that will cause food coloring to “disappear.” Write the chemical formula for sodium hypochlorite, NaClO, on the board.
4. Ask students how the outcome might have been different if you had used a different amount of sodium hypochlorite.
5. Use the Four Question Strategy to set up a procedure for this experiment:
 - Question 1. What materials are readily available for conducting experiments on _____?
 - Question 2. How do _____ act?
 - Question 3. How can you change the set of _____ materials to affect the actions?
 - Question 4. How can you measure or describe the responses of _____ to the change?

6. To begin an investigation, choose one independent variable from question #3 and one dependent variable from question #4, and perform the experiment as a demonstration for students to observe results. All other variables in question #3 must remain the same: they are the constants.

Procedure

1. Give pairs of students the opportunity to design their own experiment regarding the reaction rate of antacid tablets when reacting with water. Give each pair the following materials at their lab station: four antacid tablets, two 250-mL beakers, forceps, and a stopwatch. They may use other materials if they wish, such as an electronic balance, balance paper, watch glass, and graduated cylinder.
2. Have student pairs design their experiment, identifying the independent variable, the dependent variable, and the control. Have them clearly specify the factors that must remain constant throughout their experiment. They must also provide a clear description of the procedure they will use to perform their procedure and clearly express the hypothesis they will be testing.
3. Validate students' procedures prior to their using any chemicals or equipment in the lab.
4. After the experiments have been conducted and the data have been collected and analyzed, have students share their results with the class.

Assessment

- **Questions**
 - Why did you select the independent variables you selected?
 - What were the dependent variables you selected? Why?
- **Journal/Writing Prompts**
 - Describe a scientific question you have been considering. Using the four-question strategy, write about how you could go about investigating the question.
- **Other**
 - Assess measurement and data organization skills through lab work and the related data tables and conclusion questions.
 - Give a quiz on experimental design to assess students' abilities to label the dependent and independent variables.
 - Give a lab practical covering measurement to help assess skill level and laboratory competency.

Extensions and Connections (for all students)

- Have students present and conduct their own original research on a practical problem that they face everyday, using independent and dependent variables and making a hypothesis.

Strategies for Differentiation

- Have students use visual picture communication systems to create a graphic organizer of experimental design.
- Model how to design an experiment to include research question hypothesis, independent and dependent variables, constants and controls and a sample data table.

- Invite a local chemist to discuss scientific design and experimentation using independent and dependent variables.
- Have students relate scientific design to a problem-solving process by working with a partner to brainstorm a problem they would like to solve. Then, have students apply the experimental design to come up with a solution.