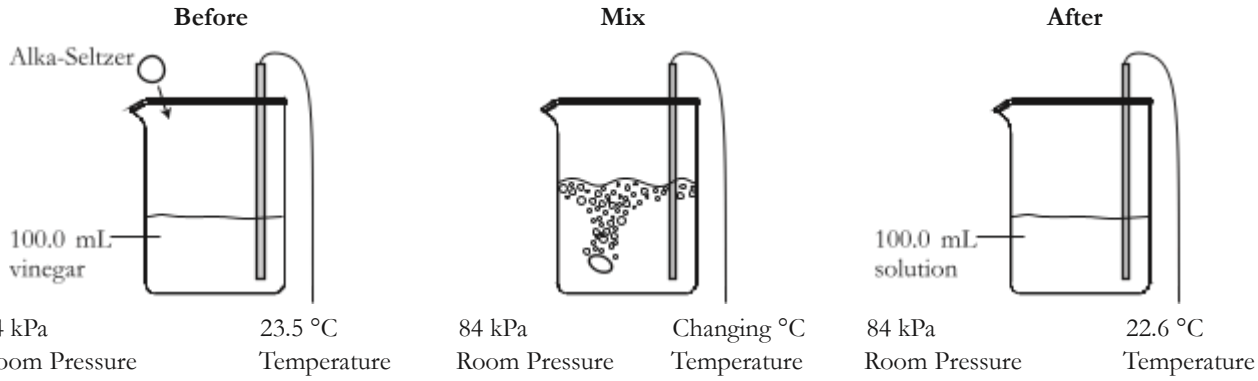
Fundamentals of Experimental Design

What is measured during a controlled experiment?

Why?

Working in the science lab can be a lot of fun. Mixing random chemicals and burning stuff just to see what happens can be entertaining (and possibly dangerous), but it doesn't lead to anything helpful to the scientific community. In order to be helpful to the community, a researcher's work in the lab must be systematic. A researcher usually asks a question and then designs an experiment to investigate that question. In this activity you will identify different types of variables that will help you design controlled experiments.

Model 1 – Alka-Seltzer® and Vinegar



1. Briefly describe the reaction illustrated in Model 1 in one or more complete sentences.

2. Did the room pressure change as the reaction occurred? If yes, was there an increase or decrease?

3. What two pieces of evidence observed during the "mix" phase of the reaction suggest that a chemical change is taking place?

4. Did the solution temperature increase or decrease during the reaction?

Model 2 – Results of Alka-Seltzer® Experiment

	Number of Alka-Seltzer Tablets	Volume of Vinegar (mL)	Room Pressure (kPa)	Initial Temp (°C) (Vinegar Solution)	Final Temp. (°C) (Final Mixture)
Trial 1	1	100.0	84	23.5	22.6
Trial 2	2	100.0	84	23.5	21.5
Trial 3	3	100.0	84	23.5	20.4
Trial 4	4	100.0	84	23.5	19.2
Trial 5	5	100.0	84	23.5	18.1

5. Which trial in the Model 2 data table corresponds to the reaction illustrated in Model 1?

6. Consider the five trials that produced the data in Model 2.
   a. What variable was purposefully changed in the experiment?

   b. What variable changed as a result of changing the variable listed in part a?

7. What variable(s) shown in the Model 2 data table remained constant among all the trials?

Model 3 – Boiling Points of Alcohols

Alcohol Name	Formula	Number of Carbons	Volume of Alcohol (mL)	Boiling Point (°C)	Room Pressure (kPa)
Methanol	CH_3OH	1	75	64.7	101
Ethanol	CH_3CH_2OH	2	75	78.4	101
Propanol	$CH_3CH_2CH_2OH$	3	75	97.1	101
Butanol	$CH_3CH_2CH_2CH_2OH$	4	75	117.7	101
Pentanol	$CH_3CH_2CH_2CH_2CH_2OH$	5	75	137.9	101

8. Describe the similarities and differences in the five alcohols used in the Model 3 experiment.

9. Consider the experiment that produced the data in Model 3.
   a. What variable was purposefully changed in the experiment?

   b. What variable changed as a result of changing the variable listed in part a?

10. What variable(s) in the Model 3 data table remained constant among all the trials?

Read This!

When designing an experiment, you need to consider three types of variables. The **independent variable** is changed by the experimenter by design. This variable is sometimes called the "manipulated variable." The **dependent variable** is what changes as a result of the change in the independent variable. This variable is sometimes called the "responding variable." In some cases more than one dependent variable is considered. The third category involves **controlled variables**. These are variables that you think might change the outcome of the experiment, but since you are not studying them, you need to keep them constant in each trial.

11. Identify the independent, dependent, and controlled variables for the experiments that produced the data shown in Model 2 and Model 3.

Model Experiment	Variables		
	Independent	Dependent	Controlled
Alka-Seltzer® and Vinegar			
Boiling Points of Alcohols			

Read This!

A well-written research question states the independent and dependent variables for an experiment. For example, a student investigated the effect of the deicer, magnesium chloride, on vegetation on the sides of highways. Her research question was, "What is the effect of magnesium chloride solution concentration on the growth of rye grass?"

12. Write a research question, using the format suggested in the Read This! box, for the experiments in Model 2 and 3.

    Alka-Seltzer® and Vinegar —

    Boiling Points of Alcohols—

13. A student wonders, "Will changing the volume of alcohol in a boiling point experiment change the boiling point of the liquid?" Identify the variables that should be considered in this experiment.

Independent	Dependent	Controlled

Extension Questions

14. Many experiments designed to investigate the reaction of Mentos® with Diet Coke® have been documented on YouTube. Design and write an experiment that uses the knowledge gained in this activity to investigate this reaction. Include a research question; the independent, dependent and controlled variables; and a simple procedure.

15. Scientists may design an experiment with a **control group**, which is a set of organisms or samples that do NOT receive the treatment (the independent variable) that is being tested. Scientists can then compare normal changes in organisms or samples with those that might have occurred because of the treatment. The idea of a "control group" is not the same as a "controlled variable." Suppose a scientist is doing an experiment to determine the effect of a cancer drug on mice with lymphoma.

    a. What are some of the variables the scientist should control in the experiment?

    b. Describe the control group for this experiment.